

Towards 2030

Teagasc's Role in Transforming Ireland's
Agri-Food Sector and the Wider Bioeconomy

Foresight Report

May 2008



Glossary of abbreviations used

BETTER	Business, environment, and technology through extension and research
CAP	Common Agricultural Policy
CHP	Combined heat and power
FAO	Food and Agriculture Organisation (UN)
FDI	Foreign direct investment
GEGA	Green Energy Growers' Association
GHGs	Greenhouse gases
IBEC	Irish Business and Employers Confederation
ICOS	Irish Co-operative Organisation Society
IDB	Irish Dairy Board
IEA	International Energy Agency
ICTs	Information and communication technologies
KBBE	Knowledge-based bioeconomy
NDP	National Development Plan
OECD	Organisation for Economic Co-Operation and Development
PCR	Polymerase chain reaction
REPS	Rural environment protection scheme
SCAR	EU Standing Committee on Agricultural Research
SME	Small- and medium-sized enterprises
STI	Science, technology and innovation
WTO	World Trade Organization

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Foreword

Dr Tom O'Dwyer, Chairman of the Teagasc Authority

A number of studies have already been done on the future of Irish agriculture, sketching out the direction that the industry will go in the immediate future. Teagasc 2030, this Foresight report, is not a repeat of those exercises.

Instead, it looks at how the economy will evolve into a knowledge economy; the role that the agriculture and food sectors will play in the new knowledge-based bioeconomy (KBBE) and how Teagasc can support and encourage such a development. This is an important report for Teagasc, because it looks at the skills and structures needed for a science-based organisation like Teagasc to support the information-driven economy of the future.

Teagasc is uniquely positioned, as its research function is fully integrated with an advisory and education service for farmers and the rural economy. This puts Teagasc in an important leadership position, not just to influence and set the agenda for change, but to follow it through with actions in the critical areas of research, advise and education.

This report is the Teagasc view on the meaning of the 21st century. I draw your attention to a book entitled, "The Meaning of the 21st Century"*¹, by Dr James Martin. Many of the drivers of change discussed in this book are relevant in the present context. We have seen an increased impact from climate change, one of the biggest challenges facing, not just the agriculture industry, but society as a whole. We have seen an erosion of food stocks and food reserves globally, with cereal prices reaching record levels over the last two years. Rising oil prices are impacting on fuel and fertiliser prices, driving up production costs on the one hand, but creating unimaginable opportunities for crop-based alternatives to oil-based products. Our temperate environment gives us a comparative advantage in grass-based production over other concentrate-based livestock production systems used by more grain-dependent international competitors.

I am convinced that the future will be about "brain not brawn", and the farmers of tomorrow will need to be increasingly sophisticated business people. The advanced farmers of today are already developing their skill sets to be competitive into the future, with increasing numbers pursuing third-level qualifications to equip them to successfully manage modern farm businesses.

We must strive to generate the knowledge required for the future, but we must also build on the scientific knowledge around the world and continuously harvest the technologies and research developed internationally and adapt and change them to Ireland's benefit. There are many drivers of change which we must note, but change provides opportunities and we must be ready to take advantage of the changes happening globally in agriculture and food production.

I would like to thank all those who have participated in this Foresight process, both within Teagasc and in the wider agriculture and food sectors, both internationally and in Ireland. Their contributions have been greatly appreciated as we work together to see into the future and plan for a dynamic period of change. In particular, I would like to thank Professor Gerry Boyle, Director of Teagasc, who fully embraced this exercise and has really driven the process since joining the organisation. He will, no doubt, continue the drive towards a knowledge-based bioeconomy, with Teagasc and the agriculture and food sectors playing a central role. The investment in science and knowledge creation to date through the national scientific programme has given us the confidence and the resources to meet the challenges we face.

* *The Meaning of the 21st Century. A Vital Blueprint for Ensuring our Future*, Eden Project Books, London, 2007



Preface

Prof Gerry Boyle, Director of Teagasc

There is now widespread acceptance that knowledge is key to economic prosperity. As one author so eloquently put it, 'knowledge is the lever of riches'. Knowledge is a unique resource. Once a piece of knowledge is publicly available, it can be used in a potentially infinite number of places at the same time. And the marginal cost of using that same piece of knowledge over and over again is virtually zero. These properties are the basis for the exceptionally high returns that have been recorded for knowledge investment. But unless knowledge is usable it will not deliver these potential gains.

Teagasc is the national body charged with the responsibility for the development of the agriculture and food sector. Its predecessor, An Foras Talúntais, was established 50 years ago this year, with the objective of developing technology that would assist the profitable development of Irish agriculture. Teagasc, established in 1988, has continued this mission, together with the additional commitment to 'knowledge transfer' through its farm advisory and comprehensive education and training services.

This Foresight Report, is in effect, an outline of the strategic direction that the organisation needs to take if it is to continue to support Ireland's agriculture and food sectors in light of the challenges and opportunities that lie ahead. It is not a forecast of the future, but an outline of the challenges and opportunities that the agri-food sector is likely to face in the next quarter century or so, such as food and energy security, climate change and environmental sustainability. The role of Teagasc as a publicly-funded organisation is to support our largest indigenous sector to overcome the challenges and exploit the opportunities.

The report stresses that our natural resources will no longer simply produce food for humans and livestock, although this will continue to be the central economic activity. In future years, we will increasingly look to our natural resources to provide our energy and fibre needs. Indeed many of the

products derived from fossil fuels that we now depend on are likely to be provided from our plentiful and renewable bio-resources. We are entering a phase in our economic development where the bioeconomy will be pre-eminent. This sector encompasses the traditional agri-food sector as its most significant component, but added to it will be newly emerging sectors such as bioenergy, bio-fibre and bio-pharma.

Another dynamic element will be high-value-added processing in areas such as infant foods, functional foods and nutraceuticals. These sectors will be driven by indigenous and foreign multi-national food companies with strong in-house R&D capacity.

Our natural resources permit not only the production of physical products, but also the provision of services such as recreation and tourism. These services have a value to users and are expected to grow in the years ahead. Value will be generated for the owners and managers of our natural resources by both the public and private sectors. Our natural resources are also becoming increasingly appreciated because of their intrinsic value in areas such as natural beauty, biodiversity and water quality. The preservation and enhancement of these will require continued public subvention because of their public-good nature.

The new emphasis on the bio-sector will require a growing emphasis on our knowledge capacity to deliver profitability and competitiveness for the producers and processors of our natural resources. Teagasc, in collaboration with relevant government departments and, especially, our parent Department of Agriculture, Fisheries and Food, state agencies, international partners, farmers and food companies, will support these exciting developments. We will also undertake the necessary structural and programme adjustments that will enable us to respond with agility, focus, and relevance to change.

The report is positive about the future. As a country we are blessed with abundant resources for the production of food, bioenergy and other bio-products. We have a strong government commitment to investment in the generation of knowledge and in education and training. We have an emerging generation that has only known the era of the 'Celtic Tiger' and who are brimming with confidence to take on the challenges of the future. There is a good future in farming and the wider bioeconomy, but that future cannot be taken for granted. Young people need the education, the knowledge and the mindset to embrace the possible. What they require from organisations like Teagasc is the support to enable them to attain, and hopefully to exceed, their ambitions.

A report like this could not have been produced without the help of many people, both within and outside Teagasc. All of the individuals and organisations that assisted in the production of the Foresight Report are listed in the appendices, but I would like to mention the exceptional contribution of some individuals.

We were fortunate to have the wisdom and steadfastness of Professor Seamus Smyth, Emeritus President of the National University of Ireland, Maynooth as the Chairman of the Foresight Steering Committee. I am particularly grateful to Dr Lance O'Brien of Teagasc who, in his capacity as Foresight Project Manager, has led the project from the outset with enormous energy and dedication and his huge intellectual input to the entire process is reflected in the high quality of the final report. He was ably assisted by Dr Owen Carton, also of Teagasc. A special word of thanks is due to the membership of the Foresight Panel, participants in the various Panel Workshops and Working Group members from both within Teagasc and especially those who gave so generously of their time from outside of Teagasc. Our consultants, Dr Patrick Crehan and Dr Guentar Clar, assisted us at critical stages of the process, as did Ms Mary Mulvihill. We are also grateful to the many individuals and organisations who made written submissions. A key part of the Foresight process is stakeholder consultation and we benefited considerably from this interaction in the preparation of the report. Finally, I want to acknowledge the wholehearted engagement by

my Teagasc colleagues throughout the organisation and the by the Teagasc Authority in the process that has led to this publication.

This Foresight Report is merely the beginning of the engagement that will take place in the years ahead as we implement the strategic directions that it contains. I look forward to that engagement and especially to the tangible benefits that I expect will accrue to farmers, food processors, rural dwellers and the wider economy and society.

Executive Summary

Ireland is entering an exciting new era in farming and food production that promises tremendous opportunities, but also considerable challenges. After two decades of relative stability but little growth and weak prices, we now face a period of opportunity for our major sectors. Young people with the necessary education and skills can look forward with confidence to a good future in farming. But these opportunities will be tempered by a level of uncertainty and pace of change that will be greater and faster than before. Innovation will be the key to prosperity as never before. This has major implications for Ireland's agri-food sector and rural economy, for farmers and firms and, especially for Teagasc, the national agency responsible for research, advice and education in this area. Against this backdrop, Teagasc undertook a detailed 18-month technology foresight exercise.

- **Teagasc 2030** : to identify the research, innovation and support priorities for the next quarter century, in consultation with stakeholders.

Agriculture and food account for over half of our indigenous exports, represent one-tenth of the Irish economy and are central to the economic and social vitality of rural communities. The sector is likely to become even more important as scientific advances, consumer trends and market developments create novel and non-traditional uses for our natural resources (Chapter 1). In the post-petroleum future, as society and industry worldwide switch from fossil fuels and petrochemicals, we will need to derive 'green chemicals' and alternative, sustainable fuels from plants and plant products. Meanwhile, Ireland's key dairy sector, which owes its competitiveness to grass production, is set for substantial expansion when the EU milk quota system is abolished in 2015.

A number of important driving forces were reviewed to determine their long-term impact on the sector, including international factors such as EU policy developments, WTO negotiations and climate change, and local factors such as demographic trends (Chapter 2). At the time of writing, the proposals contained in the Doha round of WTO negotiations will put the Irish beef industry, in particular, at risk unless they are mitigated significantly in negotiations before an agreement is finalised.

- **The driving forces :**

- commodity price trends and policy developments
- climate change
- energy supply and security
- environmental sustainability
- social and demographic changes
- market and consumer trends
- advances in science, technology and innovation.

Agriculture and food production are now part of a wider bioeconomy, which embraces all of the sectors exploiting natural resources and bio-processes to generate products and services, jobs and income. Our foresight vision for this bioeconomy is that it will become central to Ireland's developing knowledge economy and rest on four sectoral pillars, including traditional sectors and new and emerging ones (Chapter 3). A successful agri-food sector and rural economy will enhance the quality of life for everyone, as well as contributing to economic prosperity (Chapter 4).

- **The Vision :** in 2030 the agri-food sector will be a core element of a bioeconomy that will be knowledge-based, innovation-driven, market-led and internationally competitive and it will enhance the quality of life of all the people of Ireland.

- **The four pillars :**

- food production and processing
- value-added food processing
- agri-environmental products and services
- energy and bio-processing.

- **Double in value :** gross output value of the food and drink sector is expected to double from €20bn to €40bn by 2030.

- **Competitive, cost-effective and sustainable :** the agri-food sector and rural economy will compete successfully on international markets, while reducing both costs and environmental impacts.

- **Innovative** : success in all of the sectors, both traditional and emerging, will depend on exploiting new knowledge through innovation.

The 2030 foresight vision for Teagasc emerges against this background for the sector. Teagasc is, and will continue to be, an organisation that supports science-based innovation in the sector. It is a key participant in the national strategy for science, technology and innovation (STI) and is internationally recognised for its excellence in supporting science-based innovation and the development of the knowledge-based bioeconomy.

- **Teagasc's mission** : to support science-based innovation on farms and in processing firms that will underpin their profitability, competitiveness and sustainability.

The realisation of this mission will ensure that Teagasc is a respected brand, nationally and internationally, reaching into every aspect of the rural economy and the countryside. Science-based innovation support requires excellence in knowledge generation and procurement (research); knowledge transfer (advisory activity) and knowledge absorption (education and training). Teagasc combines research, advisory and educational services within an integrated agency serving farms and processing firms, government and society. This integrated structure is internationally unique and will play an important role in supporting the transformation of Ireland's agri-food sector into a fully-fledged profitable and competitive international player in the knowledge-based bioeconomy.

To realise this 2030 vision, Teagasc itself must be innovative in how it serves the needs of clients and stakeholders. To provide an excellent innovation-support service requires three key organisational capabilities: leadership, partnership, and accountability and governance (Chapter 5).

- **Leadership** : Teagasc will identify and address leadership gaps by conducting high-quality scientific research, procuring knowledge for and on behalf of our clients, developing our skills in knowledge reconnaissance

and adopting the most up-to-date knowledge transfer systems.

- **Partnership** : The complex challenges facing the sector can be addressed only through sustained collaboration and partnership with national and international organisations. Teagasc will build and foster strategic partnerships with all stakeholders to provide advice on the agendas required to support innovation and to oversee implementation. Teagasc will also draw extensively on the 'commodity advisory groups' that have been established in recent years to promote a closer involvement by our stakeholders in our work and will develop these structures as needed.
- **Accountability and governance** : Teagasc's activities are substantially funded by direct State subvention. Teagasc will ensure that continued State support for its activities is justified on a value-for-money basis, that there is no duplication of activities that could be better funded by the private sector and that stress is continually placed on the maximisation of value to the agri-sector and the wider bioeconomy.

Research will in future operate in a more open and competitive environment. Teagasc will always focus heavily on applied research of direct relevance to stakeholders, while also investing in achieving critical mass in specialist areas. The Teagasc applied research centres servicing the main agricultural enterprises and food will become "Research and Innovation Centres" by involving advisory and education and training services more closely in their activities. These centres will be supported by strategically important bioscience centres (notably in animal science, crop science and bio-energy, functional foods and nutraceuticals), an environmental research centre and a rural economics centre. The bioscience centres will achieve the critical mass that will enable them to collaborate at national and international level and achieve the required standard of scientific excellence. Working closely with the Research and Innovation Centres, they will identify and harness developments in basic science, medical science, biotechnology and nanotechnology and develop and test new concepts and applications. We will contribute to Ireland's

Research and Innovation Centres will involve advisory and education and training services more closely

growth as a provider of internationally traded services through our participation in internationally-funded research contracts and through a new emphasis on the international deployment of organisational skills and technologies.

Economic, trade and environmental policies at national and international level will continue to challenge the viability and profitability of the agri-food and wider bio-sector. With its comprehensive rural economy and environmental research programmes, Teagasc will provide leadership and direction in research, policy advice and analysis to stakeholders and Government to help meet future challenges.

- **Teagasc** will provide leadership, direction, policy advice and analysis.
- **Teagasc** will play a role in helping to grow Ireland's internationally traded services economy.

Technology platforms, or specific research programmes, will be established and resourced in areas of strategic national importance such as grassland research. These programmes will be multi-disciplinary, where researchers, advisers and stakeholders will come together to identify the priorities and research projects that will give Ireland a competitive advantage. The programmes will have clear goals and strict time limits for the delivery of workable and profitable solutions of benefit to our stakeholders.

- **Technology platforms or research programmes** : will be established in areas of strategic importance.

Teagasc will enhance its knowledge transfer to farms and firms through new approaches to programme implementation, ongoing evaluation of all programmes and initiatives and by establishing a single professional career structure across the organisation. We will also establish, in collaboration with relevant State agencies, a specialised knowledge transfer service to ensure rapid transfer of knowledge from research to the food industry, including SMEs involved in niche food-processing activity.

- **Knowledge transfer** : Teagasc will integrate its knowledge transfer function across the organisation to ensure a better service to clients.
- **Food industry support** : a knowledge transfer service will be established for the food sector in collaboration with other state agencies.
- **Client needs** : Teagasc recognises that the needs of clients, especially farmers, can vary (e.g., with local conditions, stage of life) and will tailor its advisory services accordingly.
- **Stakeholders** : Teagasc will strengthen its relationships with stakeholders and clients.

To succeed in the future, agri-food companies must be able to innovate and to absorb new knowledge. Teagasc will work to improve client companies' capacity for innovation. Initiatives will include a professional doctorate programme of placing young PhD graduates in selected firms to help those firms derive the full benefits from new developments.

Education and training are core Teagasc functions, because without them there is the risk that useful knowledge might not be absorbed by farmers and processing firms. We will enhance our third and fourth-level programmes in agriculture and horticulture, in conjunction with our third-level partners, in order to attract the best students and to prepare young people for profitable careers in the agri-food and wider bio-sector of the future. Adult education programmes will be enhanced by providing education in business development and technology adoption through our local training network. Developments in ICT offer tremendous potential to improve the delivery of our education and training programmes. We will build on the experience gained from the establishment of a very successful eCollege and will exploit communications technologies, such as video conferencing, to support group discussions, instruction and individual support, and to link with other training and innovation-support providers at home and abroad.

- **Education and training** : we will enhance our programmes, integrate our services, introduce new initiatives and exploit communications technologies to improve instruction and delivery.

Agriculture, food production and processing and the rural economy now face an era of profound change. Teagasc, through a process of organisational change and development and engagement with stakeholders, will be the key player in navigating this future and helping to put the new bioeconomy at the centre of Ireland's knowledge economy. Already, the agency has taken a number of critical initial steps, including the establishment of bioscience research centres, to ensure that science, technology and innovation are at the heart of the sector's development; the publication of a series of 'Road Maps' for the key agricultural sectors to 2015 and the creation of a permanent Foresight Implementation Unit (Chapter 6).

The long-term future cannot be predicted with any degree of precision, hence planning to cope with specific eventualities is not possible. The key requirement lies in being innovative and agile and able to respond to what the future brings. This Teagasc 2030 Foresight report is the vital first step in that process.

01 Opportunities and Challenges



Ireland is poised at the start of an exciting new era in farming and food production. The future promises tremendous opportunities, but also considerable challenges. After more than two decades of relative stability and little if any growth or change, we now face a period of sustained upheaval and uncertainty. Change will be greater and faster than ever before. This has major implications for Ireland's agri-food sector and rural economy, for farmers and firms, and for Teagasc, the national agency responsible for research, advice and education in this area.

The agriculture and food industry is Ireland's largest indigenous sector. It is of major importance to our economic welfare and development and central to the economic and social vitality of rural communities. Employing about 155,000 people, it accounts for over half of the country's indigenous exports and almost one-tenth of the economy. Turnover in the food and drink sector alone was valued at almost €20bn in 2006, and the industry as a whole accounted for at least 35% of the value added in Irish manufacturing. The sector is likely to become even more important in the coming years. First, scientific and market developments are creating exciting new uses for natural resources. Second, our key dairy sector is set for substantial expansion once the EU quota system is abolished in 2015.

We are also facing into an important time of economic change and policy reform. Global demand and prices for cereals and dairy products are rising, after years of decline in real commodity prices, bringing opportunities for those who can respond to the new demand. But, after more than 30 years of European policy initiatives designed to deal with food surpluses, there are growing concerns over the world's ability

to provide enough food, prompting former EU Agriculture Commissioner, Franz Fischler, to call for new EU policies that prioritise food and environmental security.¹

The rising price of oil has already stimulated markets for biofuels (as renewable substitutes for fossil fuels). But using agricultural land and crops to produce energy is proving increasingly controversial in the face of rising food prices and food shortages in many parts of the world. Policy reforms such as decoupling farm supports and phasing out milk quotas are removing some obstacles to expanding the sector. However, we face new challenges arising from ongoing policy and trade reform, from an unstable economic climate at home and abroad and an urgent need to focus on environmental concerns such as climate change and water quality.

The New 'Bioeconomy'

Agriculture, forestry, the marine and their related processing sectors are on the cusp of profound change. The potential for new business development is so great that it makes sense to redefine the sector into the broader concept of the bioeconomy, encompassing the traditional agri-food sector and a wide range of novel activities that can now be generated from our natural resources of land, forestry and the marine.

The bioeconomy is knowledge-intensive – indeed, it is often referred to as the “knowledge-based bioeconomy”, or KBBE - and its development depends critically on research and innovation, on creating and acquiring relevant, usable knowledge. The OECD sees it as being “made possible by the recent surge in the scientific knowledge and technical competencies required to harness biological processes for practical applications. Looking to the future, new techniques in biotechnology, genomics, genetics and proteomics will

Key Messages

For the sector : all are agreed on the need for a vibrant bioeconomy providing sustainable solutions to food and energy security challenges.

For farms, firms and policymakers : Teagasc will provide leadership in a fast-changing and uncertain climate.

For Teagasc : provide proactive leadership and customised services to clients and stakeholders.

continue to converge with other technologies resulting in potentially large-scale changes to global economies in the next 30 years.”² The European bioeconomy already has an estimated annual turnover of more than €1,500 billion and employs 22 million people; the concept of a knowledge-based bioeconomy is driving much of the research and innovation at EU level.³

Teagasc 2030

To identify the bioeconomy’s knowledge requirements and establish a broadly-shared vision for Ireland’s agri-food sector and rural economy in 2030, Teagasc undertook, in partnership with key stakeholders, a detailed Foresight exercise. Given Teagasc’s role as the leading provider of science-based knowledge to the sector, the aim was also to strengthen the agency’s strategic capabilities and its relevance to its stakeholders, enabling it to provide proactive leadership in the new and rapidly changing open-market environment. The Teagasc 2030 Foresight exercise also set out to:

- Identify the technologies, research and innovation-management strategies required to underpin the sector’s development in the short, medium and long-term;
- Identify the strategies and mechanisms needed to maximise Teagasc’s impact;
- Develop a culture of continuous renewal within Teagasc;
- Secure the involvement and support of a wide spectrum of stakeholders; and
- Create a public awareness of the importance of innovation in developing the bioeconomy.

The project was launched in December 2006. In consultation with key stakeholders, the initial process involved a review of the driving forces that, we believe, will shape the bioeconomy. This analysis formed the basis for preparing five ‘future’ scenarios for the sector over the next 20 years or so, designed to stimulate thinking about the sector’s ability to prepare for various eventualities or ‘futures’ as they emerge.

From this came our vision for the sector in 2030: a vibrant bioeconomy providing sustainable solutions to Irish, European and international challenges related to food and energy security and the need for new bio-products in the post-petroleum era, and contributing to wider social goals, such as better public health from improved food products and an enhanced rural environment.

National and international representatives from government institutions, industry and universities joined a steering committee responsible for the overall direction of the Teagasc 2030 project (Appendix 1: Foresight project teams). Experts from Teagasc and from a broad range of stakeholder organisations, including Government departments, other State bodies, universities, farming and rural organisations, as well as the food and related industries (the Foresight panel), were responsible for information gathering and analysis, scenario building, strategy development and reporting. External consultants provided advice and assistance throughout.

The organisation consulted with key industry stakeholders, with policy makers, other State-support organisations, as well as experts from third-level education and research. A significant number of Teagasc staff members also contributed directly to the work. The main background work was conducted in seven workshops between January 2007 and January 2008 and in other special information-gathering events and research. From the outset, communication and consultation were important and Teagasc publicised the

Foresight 2030 Vision

Foresight is a widely recognised process for assessing future opportunities and challenges. The EC’s Directorate-General for Research defines it as: “a systematic, participatory, future intelligence gathering and medium-to-long-term vision-building process aimed at present-day decisions and mobilising joint actions.” EC Directorate-General for Research, *“Thinking, Debating and Shaping the Future: Foresight for Europe”*, Report of a High Level Expert Group, Brussels, 2002.

project widely using a dedicated website, brochures and eBulletin.

The findings of this detailed and intensive exercise are outlined in chapters 2-4 of this report. Chapters 5 and 6 present the strategic and short-term actions which Teagasc will pursue. Actions arising from Teagasc 2030 will be important in enabling the agri-food sector and the broader bioeconomy to take advantage of new opportunities and to meet the emerging challenges. The findings will also feed into the ongoing national policy debate, specifically the review of the EU SCAR Foresight⁴ and the Irish AgriVision 2015 reports.

The results of the Teagasc 2030 Foresight exercise build on the earlier report and take a longer time horizon. Our findings set the agenda for the sector's development over the coming years and for the repositioning of the sector at the core of the new bioeconomy, as well as redefining the role of Teagasc in supporting the sector.

AgriVision 2015

AgriVision 2015 (published in 2004 by the Department of Agriculture and Food) examined changes likely to occur within the agri-food sector over the following decade. Prepared by a committee appointed by the then Minister for Agriculture and Food, it focused on the implications of:

- The mid-term review of the Common Agricultural Policy (CAP);
- EU enlargement;
- Developments in the World Trade Organization (WTO) Doha negotiations;
- Competitiveness and efficiency of the production base; and
- Income and employment trends in agriculture and rural areas.



After decades of little or no growth, the prices of food staples are rising dramatically – wheat prices climbed by 130% in the year to March 2008.

02 The Drivers of Change



New and emerging technologies, social and economic changes and policy reforms will shape the bioeconomy over the next 25 years, creating a complex, unpredictable and challenging environment. Here we identify seven key factors that we consider will drive change in the agri-food sector and rural economy over the coming quarter century. Understanding these factors will be crucial to responding proactively and building a successful bioeconomy.

Agriculture is not like other industries: it operates at the mercy of the weather and is constrained by numerous other variables such as soil and location. This makes its outputs inherently unpredictable. To this unpredictability, we must now add the changes likely to come from other driving forces, such as emerging technologies and policy reform. The key to successfully responding to the myriad changes will be flexibility and innovation, acquired through research, advice and education. It is this that will ensure that Ireland's agri-food sector and rural economy will not just keep up with change, but succeed in the new fast-changing environment. To successfully manage unpredictable change, we must first be able to respond to predictable change. That means developing realistic and reliable scenarios and identifying and understanding the key factors that will shape the 2030 bioeconomy. In this Foresight exercise, we identified and reviewed what we believe are the seven most important drivers of change in the agri-food and rural economy sectors. These are:

- Commodity price trends and policy developments;
- Climate change;
- Energy supply and security;
- Environmental sustainability;
- Social and demographic changes;
- Market and consumer trends; and
- Advances in science, technology and innovation.

Our analysis of the drivers of change was based on a series of detailed background papers commissioned from Teagasc staff. These papers are produced on the CD included in the Foresight 2030 pack and are also available at www.teagasc.ie.

1 : Commodity Price Trends and Policy Developments

World prices for agri-food commodities will be strongly shaped by continued world population growth, combined with income growth in developing countries, climate change in major food-producing nations and biofuel-related land-use changes. After 50 years of falling real prices, we are now seeing an extraordinary reversal in agricultural commodity prices, especially in cereals, oilseeds and dairy products. This will dramatically alter the market environment for both producers and processors. Ireland's agri-food industry will probably have to adapt to a more liberalised world trade regime. Rising commodity prices will increase the incomes of some producers, but increase the costs for others and may put pressure on livestock farmers who rely on cereals and other crops for animal feed. Meanwhile, increasing energy and labour costs will also put pressure on margins. Hard-to-predict variations in weather, policy and economic conditions in all countries will add to price volatility and uncertainty and render decision-making ever more complex in many sectors. Since the mid-1980s the EU CAP has progressively shifted

Key Messages

For the sector : the future will be uncertain, complex and challenging and all participants in the sector will be affected. Clearer market signals should make decision-making easier.

For farms, firms and policymakers : there will be new challenges to face and new opportunities to exploit.

For Teagasc : provide leadership in addressing these forces and respond proactively to the uncertain future.

towards direct support for farmers' incomes, and on average, these payments now account for 80% of net farm income. CAP and WTO reforms in the near future seem certain to lower the level of tax-payer and consumer support to agriculture in general; in the long-run, direct support

Farming as 'Rocket Science'

Jet fuel is one of the many petroleum products that may eventually be replaced by plant-based technologies already in the pipeline. In 2007 and again in 2008, controversial US biotechnologist and entrepreneur, Craig Venter, made headlines with his progress in creating synthetic micro-organisms designed for tasks such as converting plants and algae to valuable industrial products such as diesel, ethanol and even jet fuel. The Venter Institute aims to create renewable bio-jet fuels, research that could create new industrial sectors and new markets for farmers.

to farm income is likely to be replaced by support for the development of the rural economy. The challenge for the Irish agriculture and food sector will be to compete successfully in a market environment with less and less government intervention - although government regulation may increase in areas such as food quality and the environment and in providing support for innovation and competitiveness. The net effect of these policy changes and trends is that agricultural and food enterprises will be more exposed to market forces. This will put pressure on less competitive enterprises, but generate clearer market signals for improved decision-making and create new opportunities for innovative farmers and companies capable of adapting to the changed market needs.

Policy will remain a key driver of the Irish and European agri-food sector. A recent EU Foresight report⁵ identified food and energy security as key challenges into the future and called for debate on new policies, technologies and knowledge that will enable Europe to successfully face these challenges. Innovation to improve farming and business processes will



World prices for commodities, especially for dairy products and cereals, are now rising dramatically leading to food inflation.

become even more critical, but higher world prices should make it easier for industry to invest in the changes needed to improve productivity and competitiveness. For individual farmers and processors, this will require that their activities become more closely aligned with market needs. At a sectoral level, policy changes will inevitably lead to restructuring in production and processing, while some processors could face shortages of raw materials. Science, technology and innovation will be crucial in achieving the increased competitiveness, productivity and flexibility required to prosper in this new environment.

WTO Doha Round

The Doha round of the WTO will conclude within the next five years and possibly as early as 2008. The broad parameters of a future agreement on agricultural trade liberalisation are now clear: the agreement will focus on reforms to the “three pillars” of: trade-distorting domestic support, export competition and market access. The decoupling of direct payments from production in the CAP reforms of 2003 and the “green box” status of decoupled direct payments within the WTO negotiations, probably mean that proposed reforms to domestic support will not greatly affect EU agriculture. Changes to the rules governing market access (tariffs) and export competition (export subsidies) will have a significantly negative impact on Irish agriculture when compared to an alternative where no change in trade rules occurs. A WTO agreement on the basis outlined above will probably result in significant reductions in Irish agricultural output prices. It is likely that the largest negative price impacts will be felt in the dry stock sectors, followed by the dairy, pig and tillage sectors. The impact of a WTO agreement on agricultural output prices will be reflected in lower volumes of agricultural output and lower agricultural sector income. Lower prices and lower rates of profitability will probably accelerate structural change at farm and industry levels.

2 : Climate Change

Since the mid-20th century, weather conditions on the planet have been changing. These include changes to average, maximum and minimum temperatures, average rainfall and the number of days without rain, as well as altered wind patterns. Climate change is real and it is now generally accepted that the change is due to the large quantities of greenhouse gases (GHGs) released into the atmosphere by such human activities as construction, agricultural production and the burning of fossil fuels.

Agriculture releases significant quantities of the major GHGs, notably carbon dioxide, methane and nitrous oxide. Worldwide, farming accounts for approximately 13% of GHG emissions, comparable to that of the transport sector. In Ireland, agriculture’s contribution to GHG emissions is 28%, down from about 31% in 1990. While agriculture contributes to GHG emissions, it also has the potential to help mitigate emissions through processes such as carbon storage or sequestration.

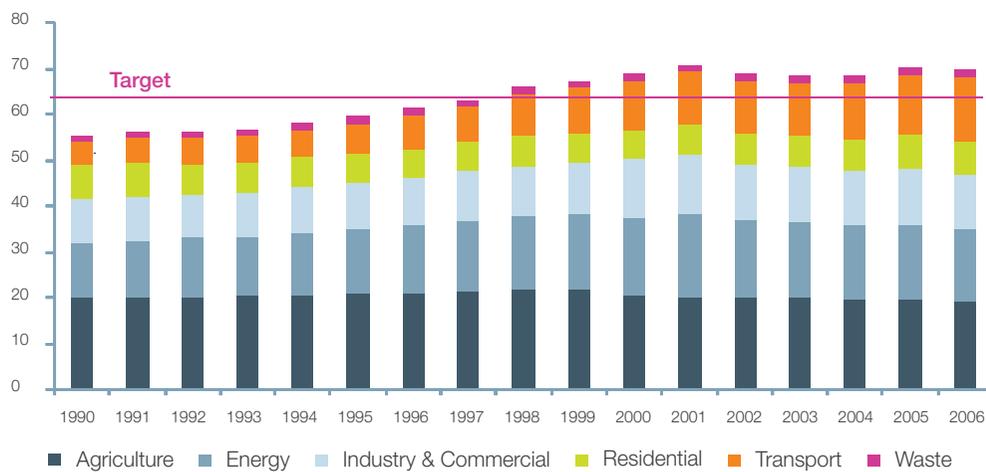
Climate change could bring new pests and diseases to our shores – blue tongue, an insect-borne disease, has already spread to Britain, due in part to milder winters and the first case on the island of Ireland was detected in February 2008. Changes in seasonal temperature variation and rainfall patterns could result in flooding, drought, higher sea levels and more frequent extreme weather events. In the medium-term, these changes could benefit higher latitudes by enabling the introduction of new crop varieties, increasing yields and expanding areas of land under cultivation. In the long-term, however, the net benefits are less certain, particularly in lower latitudes where droughts and desertification will create significant social challenges in some of the world’s poorest economies.

Reducing agriculture’s GHG emissions must be considered in the context of a growing world population and increased demand for food. The drive to substitute fossil fuels with renewable biofuels, prompted by concerns about fossil-based energy supplies and climate change, has seen food crops increasingly replaced by energy crops, exacerbating food security concerns. Some question a GHG policy that would



Climate change could bring more flooding and drought and more frequent extreme weather.

Figure 1 : Trend in total and sectoral GHG emissions for Ireland 1990-2006



Source: McGettigan, M., Duffy, P., Connolly, N., Hyde, B., O'Brien, P., *Ireland -National Inventory Report 2007*. EPA, Johnstown Castle Estate, Ireland.

reduce Irish agricultural activity at a time of increased demand for food and renewable energy sources. There are complex trade-offs to consider: effective solutions to climate change may require integrated multi-sectoral approaches based on new sources of energy and industrial feedstock, new technologies for emissions capture and reduction as well as new mechanisms for balancing an immediate need for food and energy with the long-term goal of sustainability.

The EU has proposed new 2020 emission targets following the recent adoption of the Bali Road Map. These include EU-wide cuts of 14% relative to 2005 and 20% relative to 1990. For Ireland's emerging bioeconomy, these proposals mean a 20% reduction in emissions with stringent limits on the use of carbon offsetting and carbon credits. If a global GHG agreement is implemented, the EU has agreed to a further 10% cut. Ireland's agriculture sector will come under considerable pressure to reduce emissions.

Climate change presents challenges and opportunities for Ireland's bioeconomy. The challenge: to reduce its environmental impact and GHG emissions. The opportunities: provision of public goods and services, such as carbon sequestration, to mitigate climate change; production of the next-generation biofuels to replace fossil fuel fractions such as petrol and diesel; and production of heat and electricity from biomass. The sector must also develop adaptation strategies for the time when the impact of climate change here becomes significant. In the long term, several issues need to be addressed, including future choices of food and non-food crops for cultivation, how to combat new pests and diseases, managing the effect of extreme weather events, moving towards sustainable energy use, the availability of good water resources, protection from flooding and the conservation of biodiversity.

3 : Energy Supply and Security

World demand for energy will increase in the period to 2030, while fossil fuel reserves will decline, bringing increased demand for alternative, renewable sources of energy, such as wind, wave, tidal, solar and geothermal energy and sustainably-produced biofuels. Biomass has the advantage of being very versatile, as it can be used to produce heat, power

and transport fuel as well as bio-products. New technologies will bring opportunities for more efficient biofuel production and for second-generation biofuels made from non-food crops. Hydrogen, itself an attractive energy source, may one day replace fossil fuels in the energy economy and biomass is the most versatile non-petroleum resource to fuel hydrogen production. Globally, increasing attention is also being turned to new generation nuclear power.

First-generation biofuels rely on food crops for feedstock and this has, in part, been responsible for recent increases in the prices of food commodities and basic foods. First-generation biofuels are far from perfect: some critics claim that they require more energy in their production than they yield, others that they may exacerbate global warming because their use releases greenhouse gases. Nevertheless, they are a first step towards better, fully sustainable systems now being developed by public research institutes and commercial companies. Second-generation biofuels will rely on new ligno-cellulosic technology (to convert wood, wastes, etc. to sugars). The advantage is that these feedstocks do not rely on food crops, but on forests, switchgrasses, municipal and agricultural wastes. Marine algae may also be important in second-generation biofuels. Third-generation biofuels will exploit improved feedstocks such as new 'optimised' crop varieties developed using current bio-techniques. Fourth-generation biofuels will harness emerging disciplines such as synthetic biology to create optimal feedstocks and conversion processes based on enzymes from specially designed organisms. It is difficult to predict how these technologies will evolve, but Ireland has the option of being a part of this 'third industrial revolution' and Teagasc has a role to play in

Energy Policy Targets

Ireland and the EU are aiming for:

- 5.75% biofuels by 2010, and at least 10% by 2020;
- 30% biomass co-firing in Ireland's three peat-burning power stations by 2015;
- 5% of heating produced from renewable sources by 2010 and 12% by 2020; and
- 16% of all energy from renewables by 2020.

helping identify appropriate niches in these new and emerging sectors.

EU and national energy policy targets favour bioenergy sources. The Irish Government views sustainable bioenergy as contributing to policy objectives in energy, environment and climate-change mitigation, as well as in the development of rural regions and indigenous enterprise, and has introduced several policies and initiatives to promote renewable energy use and encourage a renewable energy sector.

With a moderate change in land use from dry stock to perennial biomass crop production, Ireland could produce significant amounts of biomass for electricity and heat generation and significantly reduce annual CO₂ emissions. A vibrant bioenergy industry would provide farmers with additional income streams and boost the wealth of rural communities. Future policies are likely to consider how bioenergy could complement broader energy supply and GHG reduction policies, while maximising the benefits to farmers and processors without harming other sectors.

4 : Environmental Sustainability

A rigorous scientific effort is needed to exploit the opportunities of the bioeconomy, while conserving the natural resources on which it is based. In 2001, the European Council added the environment to its economic and social reform pillars to create the 'Gothenburg Agenda', ensuring that environmental protection is now systematically integrated into all EU policies. Current environmental priorities include climate change, sustainable transport, public health issues and the responsible management of natural resources. Ireland's environmental strategy⁶ reflects this Gothenburg agenda and identifies the main challenges facing Ireland as:

- Limiting and adapting to climate change;
- Tackling air pollution;
- Protecting water resources;
- Protecting soils and biodiversity; and
- Using natural resources sustainably.

Significant scientific progress has been made in understanding how our economic and social activities impact on the natural environment, resulting in policies, regulations



What fuel will we fill our cars with in the post-petroleum era?



The years to 2030 are likely to see additional legislation to protect natural resources and biodiversity.

and improved management practices. Nevertheless, the natural variability of soils, unpredictable weather, different farming systems and the varying scales at which impacts occur, create significant challenges in targeting environmental support and advice. The support and advice that intensive farming systems need to meet basic levels of environmental regulation differ from those required by extensive systems that receive payment to maintain and enhance areas of high environmental quality.

Agriculture, forestry and maritime activities affect our water, air, soil and biodiversity and protecting these natural resources is a priority under the CAP. Ongoing CAP reform is relevant to sustainable land use through a variety of policy mechanisms (e.g., cross-compliance, less-favoured areas, Natura 2000, high-nature-value farmland, forestry, and agri-environmental schemes). There is considerable uncertainty about CAP reform post-2013, but there is likely to be increasing focus on environmental effectiveness and economic efficiency. Policies will still be influenced by societal

preferences, although more affluent societies typically demand greater environmental quality and related amenity values. The years to 2030 will likely see more environmental regulation to protect water, air, soil and biodiversity, especially if these natural resources are exposed to new threats.

In many cases, environmental sustainability will coincide with the aims of production systems striving for high nutrient efficiency. As energy and fertiliser costs increase, there will be an even stronger incentive to develop production systems that retain and recycle nutrients, thereby reducing energy and fertiliser costs. New bioeconomic sectors, such as biofuel and industrial feedstock production and on-farm green-energy production from wind or anaerobic digestion, will put new pressures on the environment in ways that we do not yet fully understand.

5 : Social and Demographic Change

For decades, Ireland's rural communities remained relatively settled, although many lost population to the cities and

40% of farmers will retire by 2020 and most farms will change hands at least once by 2030

to overseas emigration. In the past 10 years, however, many have experienced a dramatic change and rapid and often unexpected expansion of population. In future, the composition, structure and welfare of rural populations will depend to a large extent on the design and implementation of public policies and economic strategies. If development is unmanaged, economic activity will continue to concentrate around the greater Dublin area and other cities, exploiting the critical mass and agglomeration economies associated with urban areas. This type of development puts pressure on physical infrastructure, the environment and quality of life.

Various planning documents promote balanced regional development - notably the National Development Plan 2007-2013 (NDP), the National Spatial Strategy and the Rural Development Programme-Ireland, 2007-2013 - and the growth of the bioeconomy can play a significant role in this process. New infrastructure planned under the NDP will increase the connectivity of the regions, making rural areas more attractive places to live and work. But, without accompanying economic development, there will be no real community development and instead we will see a growth in commuting. Decisions on where to locate public services will also affect the quality of life in rural areas and already there is public concern about the concentration of services, especially health-care, required to achieve economies of scale.

Within agriculture, we expect to see a continued trend towards two contrasting types of farm: large-scale full-time farms and small-scale part-time ones. Approximately 40% of

farmers will retire in the next 10 years and almost all farms will change hands at least once by 2030. The extent of part-time farming will depend on the willingness of offspring to continue to hold at least one other job and the availability of additional local employment. Factors that promote or hinder the transfer of agricultural resources, such as farm succession and the availability of off-farm employment, will be crucial in facilitating farm restructuring and shaping the future of the agricultural sector.

Restructuring will also depend on the availability of productive land. Most Irish farming is grass-based and therefore extensive, hence the availability of land is often a limiting factor. With long-term pressure on land prices, the amount of agricultural land available for sale will remain small, making it almost impossible to enter farming other than through inheritance. Unless new policies can facilitate the entry of 'new blood', the structure of the farming population, in terms of farm size, ownership and labour, is unlikely to change significantly between now and 2030.

Changing demographics may provide an opportunity for some structural change and we should explore measures that would enable successful farmers to increase the area of land they cultivate, while allowing less successful ones to move on, perhaps using models based on leasing.

Off-farm employment will be an important component of farm household income, while producers will still need local supplies of inputs, capital and labour to operate their farms. Infrastructure in rural communities will be critical both in supporting agri-food production and in linking this production to the demand in urban areas and export markets. Hence, vibrant rural communities will be critical to providing a strong base for Irish agriculture.

6 : Market and Consumer Trends

Current estimates indicate that global food consumption will double over the next 30 years, driven by population growth and rising prosperity, especially in the emerging economies. The World Bank forecasts that by 2025 China will be the world's largest single economy; the UN predicts that by then China and India alone will account for over three billion

High-rise Farms

Urban agriculture is important in the world's major cities. Some US environmental scientists calculate that a 21-storey urban greenhouse would cost \$84m to build and be as productive as 238 ha. of farm-land. Running costs could be as low as \$5m per year with annual revenues of \$18m. Projects such as these have attracted the interest of venture capitalists and companies such as Coca-Cola, Nestle, Kraft and IBM.



By 2050, the world's population will hit 9.2 billion and 60% will be Asian.

people, or 37% of the earth's total population; other Asian nations will add about 20%, giving Asia 60% of the world's total population by 2050. Clearly, Asia looks set to become the dominant purchasing block in the future.

It is not just total population size – an estimated 9.2bn by 2050 – and location, other factors also shape food markets, such as the age profile, age-related shifts in food preferences, concerns about diseases of affluence such as obesity and diabetes, as well as concerns for health, wellness and lifestyle. These trends will drive demand for conventional foods, but also shift the processing sector from food companies to health, nutrition and wellness companies, with a greater link between food and pharmaceuticals and the development of a so-called 'phood' and 'bepherage' market, with food choices possibly even personalised to an individual's metabolic health.

Increasingly, well-informed consumers are demanding freedom of choice through the use of intelligent labelling. They appreciate the health impact of food and food production, thanks to public education campaigns and look to food to

provide specific health benefits. Processed foods will become even more popular among time-stretched consumers, but there is also growing interest in buying local or organic foods, which bodes well for Irish products and for the development of farmers' markets.

The market place is becoming increasingly complex and dynamic, where retailers have considerable influence both up and down the supply chain and are the key interface between farmers, processors and consumers. Only agri-food systems that meet the standards and conditions laid down by retailers will be able to supply this growing market. Consumer preferences lead to the development of niche markets and so production methods (e.g., environmental practices and food production processes) must adapt to and support the expansion of these markets, while food producers and processors will need to continually address consumer needs and find new ways to segment and understand the market. Novel technologies and farmer-processor innovation processes, as well as education and knowledge transfer, will be key to achieving this understanding.

7 : Advances in Science, Technology and Innovation

Science and technology will be essential to the bioeconomy, enhancing its capacity to compete globally by 2030. Knowledge generation, or research, and knowledge transfer, or advice, are crucial to creating and adding value. Key enabling technologies have the power to transform food production and processing and open up new opportunities for farms and firms in the broader economy. The relationship between food and human health and wellbeing, for example, will drive consumer choice. Functional foods, with scientifically-substantiated health claims, could improve consumer health while providing industry with high added-value opportunities for product diversification. The convergence of the agri-food sector with key enabling technologies, such as nanotechnology, computer science, life sciences and robotics, presents tremendous potential for transforming food and non-food production in the period to 2030. This convergence could also improve the sector's environmental sustainability.

The agri-food sector's long-term viability depends on maintaining and building capacity in existing areas, such as food and ingredient formulation, sensory science, food safety and environmental science. The agri-food sector will also need to strengthen its capabilities in a number of new and novel technologies (see Key Technologies).

The application of advances in science and technology will help maintain the sector's competitiveness, and developing the industry's innovative capacity remains a priority. However, there has been significant consumer opposition to some technologies and this must be considered in any future strategy. There will be a need to demonstrate benefit to the consumer and provide the necessary information to allay fears both in terms of personal and environmental safety and to underpin consumers' informed decision-making.

Future Tense

These seven drivers and the changes they bring will pose significant challenges for food, agriculture and the rural economy. Directly or indirectly, they will also create opportunities. Although each of these drivers is discussed in isolation, in practice they will occur simultaneously and

are likely to interact in ways that are complex and difficult to predict, making it hard to identify the nature and magnitude of the challenges and opportunities that will be experienced by the many players in the agri-food supply chain.

Farms, firms, organisations and governments must prepare for this more complex and uncertain future, continually reviewing and revising their activities. 'Business as usual' is not an option. Participants in the bioeconomy must prepare and put in place the staff, funding and knowledge resources needed to ensure flexibility and adaptability. This will position them to overcome the challenges and grasp the opportunities through entrepreneurship, innovation and determination.

Policy reform and the globalisation of markets for agricultural and food products mean that Ireland will face competition from Brazil and other members of the Cairns group, who now exploit modern technologies, including GMOs, have cheaper labour and can produce on a vast scale.

The Irish food industry will find itself in a more competitive environment and its economic health will depend on an ability to maintain or expand market share, both at home and abroad. This means producing what consumers want at internationally competitive prices and with the required quality. Many of our food companies already face cost pressures and lack the capacity to adopt new knowledge and technologies. Our beef and dairy sectors need to achieve greater efficiencies and scale, for instance. Rising energy prices, combined with climate change, could affect food supply chains and EU and national targets for biofuels could lead to more costly raw ingredients, thereby eroding margins.

Exploiting new market opportunities in bioenergy or green-chemistry will depend on favourable policy intervention, for example, through procurement policies and lead market initiatives. Conversely, existing regulations introduced under different circumstances could inhibit the emergence of new sectors. For example, at a time when the abolition of EU milk quotas offers the tantalising prospect of growth in the dairy sector, climate change policies and emission targets could limit this opportunity. The challenge for policy makers is to create a space for opportunity, investment and growth,

Key Technologies

Biotechnology : already important in the agri-food industry, it continues to generate new tools and techniques based on molecular and genomic approaches to food, nutrition, health and wellness, promising greater efficiency for producers and processors and additional benefits for consumers. In foods, it will allow better and more efficient use of raw materials and by-products through improved and novel enzymes and microbes optimised for fermentation. Biotechnology should also improve food safety and ensure traceability across the food chain. For example, state-of-the-art PCR-based tests will radically cut the time it takes to find and identify pathogenic bacteria in food, while increasing the sensitivity at which pathogens can be detected.

Information and communication technologies : the ICT revolution, probably the key technology of the last 25 years, has already had a considerable impact on production and processing. It will continue to drive innovation in the period up to 2030, especially in logistics and distribution, productivity, food health and safety, traceability and services.

Robotics : ICT facilitated the development of robotics and automation now used in many industries, including the agri-food sector. New systems, such as self-milking systems for dairy cows, are being developed, as well as process automation to reduce labour and improve productivity.

Nutrigenomics : this is based on the premise that if we know a person's genes and lifestyle, we can design an optimum personalised diet. This may seem futuristic, but it is already being practised, albeit on a limited scale.

Nanotechnology : manipulating material at a scale measured in billionths units (e.g., nanometre nm) can dramatically change the taste, texture, appearance and functionality of foods and food ingredients. The agri-food industry is only beginning to explore applications, but potential benefits are likely to arise across the board, from packaging through to targeted delivery of biofunctional ingredients.

Management science : innovation, world-class performance and excellent productivity depend on rigorous scientific management. Processes are just as important as products. The majority of innovations are incremental and much of the value-added by innovation occurs at the process level. Techniques to improve processes, productivity and quality, to explore new markets, manage risks and control costs can all be learned. Applying management science to business and its processes is just as important for success as developing new products to meet evolving consumer needs. Historically, these techniques have been mainly applied to the manufacturing and service sectors, but there are significant gains to be had in agricultural production and all related processing sectors.

balanced with the long-term need for sustainability. This will create conflicts' and tensions that only policies, co-operation and new science, technology and innovation can resolve.

A liberalised trade environment opens new opportunities to increase Ireland's share of the large markets in emerging

countries such as China and India, where burgeoning middle classes with rising disposable incomes want a greater range of value-added products. As these countries become more urbanised, demand for exotic imported foods will grow over that for traditional, domestic foods.

The playing out of these challenges and opportunities suggest that Ireland can have a globally competitive commodity food production sector in 2030 and a stronger food processing industry. The commodity mix will probably be similar and remain centred around grass-based livestock production. However, Irish food products are likely to become more value-added and be complemented by new and emerging sectors, such as crops for energy and industrial feedstock, 'pharming' activities and a high-tech service economy based on health and nutrition. The market for agriculturally-based products and services will also grow. The competitiveness of these various sectors will depend increasingly on the quality of Irish science and the ability of Irish entrepreneurs and entrepreneurial farmers to harness global expertise.

Many policies already have a significant influence on various stages of the agri-food supply chain and this is likely to continue toward 2030. Although the bioeconomy will be affected by land use and trade policies, it will also be influenced by policies related to education, entrepreneurialism and knowledge innovation. A key contribution of knowledge will be in supporting policymakers in policy design and implementation. Leadership will also be required to ensure that the sector can participate in, contribute to, and anticipate policy changes and hence respond more proactively.

This vision of a knowledge-based rural economy depends on the industry embracing scientific innovation in all aspects of the business, to maximise potential in food and feed and to expand into bio-materials, bioenergy and bio-pharmaceuticals.

Knowledge - Build it or Buy it?

Knowledge is a significant input for any successful product or service. Do you create the knowledge you need, perhaps at great expense and with considerable uncertainty and delay, or do you source it from somewhere else?

In 2006, the Danish government established a globalisation council to consult with industry and society on how to become one of the world's most competitive economies by 2015. A key realisation was that Denmark produced about 1% of the world's research, yet Danish companies needed access to the other 99% to compete globally. This illustrates an important difference between 'doing research and doing innovation'. The challenge for research systems is to choose wisely the 1% they perform and to do it well. The challenge for innovation systems is to gain access to the other 99% of useful knowledge. As a result, Denmark set up a network of innovation centres, run by the Ministry of Foreign Affairs, in places such as Silicon Valley, Shanghai and Munich.



Harnessing Bioactive Properties of Tomatoes

UK company Provexis plc makes Fruitflow®, a functional food ingredient, from tomatoes. Tomato consumption is associated with good cardiovascular health and some of the benefit may be related to effects on blood platelets. Provexis has developed a tomato extract with specific antiplatelet properties, for which it claims an ‘8-18% reduction in platelet aggregation within three hours of consumption’. Development work to produce different formats of the tomato extract for use in different food matrices was carried out at MTL pilot plant at Teagasc’s Moorepark Food Research Centre, taking advantage of the wide range of pilot-scale equipment and expertise available on site. The Fruitflow ingredients are now being incorporated into mainstream food products, such as fruit juices and fat spreads, in collaboration with global food industry partners.



03 The Vision for an Irish
Knowledge-based Bioeconomy

The long-term future of Ireland's agri-food sector and rural economy lies in a knowledge-based bioeconomy. The Foresight exercise concluded that this will rest on four pillars: the traditional areas of food production and processing and value-added food processing; the somewhat newer area of agri-environmental products and services; and the emerging energy and bio-processing, or 'green chemicals' sector. Here we outline this broadly-shared vision and the characteristics of the four pillars.

The Vision

The 2030 agri-food sector will be a core element of a knowledge-based bioeconomy that will be innovation-driven, market-led and internationally competitive, and will enhance the quality of life for all the people of Ireland.

Stewardship of Ireland's natural environment and resources will be at its core. It will:

- Use knowledge to support innovation and to link agriculture, food and forestry to other economic sectors, with a strong emphasis on renewable energy, bio-industrial raw materials and strategies to mitigate or adapt to climate change;
- Contribute to European and national food and energy security;
- Provide farmers with a wider range of opportunities;
- Provide entrepreneurs, agri-business, food, energy and bio-product processors with investment opportunities in new technologies, industries, products and services;
- Respond in an agile manner to economic and market demands and to the broader social and ethical demands of a more sophisticated and informed society;
- Contribute directly to balanced regional development and indirectly to the creation of sustainable employment and exports in other economic sectors;
- Create a rural environment that underpins a wide range of economic and social activities that are essential for good quality of life.

Key Messages

- The future of the agri-food sector and rural economy lies in a knowledge-based bioeconomy.
- This is a broadly-shared vision for the sector's future.
- The four pillars are:
food production and processing;
value-added food processing;
agri-environmental products and services;
and energy and bio-processing.
- The first two are likely to be the biggest contributors to the bioeconomy.
- Development of energy and bio-processing will depend on national ambition and policy.

The four pillars of this future bioeconomy, identified by the Foresight exercise, are: food production and processing, value-added food processing, agri-environmental products and services, and energy and bio-processing. In the 2030 economy, the first three will, we believe, maintain their current relative contributions; the extent to which the fourth pillar develops will depend on national ambition and policy.

Food Production and Processing

In 2030, this pillar encompasses farmers and growers who produce food for human and animal consumption, from meat and milk-based products to crops, vegetables and farmed fish, as well as the processors engaged in adding value to raw materials, such as dairies, millers and meat processors. It is knowledge-based, innovative, competitive, sustainable and:

- Produces food that is high-quality, safe, traceable and secure;
- Is well-informed of market trends, with close links to processors, retailers and consumers;
- Has a strong entrepreneurial and innovation culture at all points in the production and processing chain;
- Employs practices that are profitable, because they focus on efficiency, competitiveness, sustainability and responsiveness to market needs;
- Focuses on building capability through advisory and educational support programmes;
- Comprises educated, skilled and entrepreneurial owners and managers supported by a technically skilled workforce; and

- Is supported by a marketing strategy that helps differentiate Irish food products on global markets.

Grass-based dairying, Irish farming's dominant sector, now has fewer but generally larger farms producing twice the volume of higher quality milk as 20 years ago. Innovations include automated robotic milking systems with in-line sensors to detect heat, mastitis and other markers of ill-health. Grassland management, technology adoption and management skills characterise the industry and contribute to its international competitiveness.

Grass also provides the basis for a significant beef industry based on animals from the national suckler herd, culled cows and male calves from the dairy herd. Advances in reproduction technology, including semen sexing and embryo culture and implantation, mean that all calves not required as dairy replacements can now be males of the quality and type needed to meet market demands. Sheep remain an important enterprise on part-time farms and on some mixed large-scale



On the farm : grass-based livestock production will still dominate Irish farming, but we will also be producing biomass and novel bio-chemicals.

Irish agriculture's greatest export may one day be intangible assets such as know-how and management skills

farms and also provide a landscape management function on hills. The pig and poultry sector is highly technical and efficient, operating in an environment of high costs and strict environmental regulations.

Tillage crops are dominated by a relatively small number of large growers farming 0.5 million ha of land. The focus is on wheat, barley and oats mainly for animal feed; biomass and oil seed crops for energy; and 'pharma' and 'feedstock' crops for the food, pharmaceutical and other industries. This is a sector that prioritises new knowledge and technologies to maintain its international advantage.

Ireland now has a substantial organic farming and processing sector, with about 10% of land in organic production. Crops and livestock are processed locally for local and export markets.

Markets for 'Know-how'

For the last ten years the Danish government has provided soft loans to help Danish farmers operating in Eastern Europe, Russia and the Ukraine. More than 1,000 Danish farmers now have operations outside Denmark, and they are especially strong in pork production. By operating abroad they effectively export something more valuable than pork or pork-based products: they export their knowledge of pork production and how to manage it, leveraging their knowledge and networks in global markets for pork products. They are not alone. French wine-makers are developing vineyards in China. Dutch flower growers use serviced greenhouse systems near Shanghai. The Chinese grow rice in Africa and the Philippines. The Irish manage dairy farms in Australia, America and the Middle East and grow cereals in South America. The most significant export of Irish agriculture may one day be, not products such as milk-powder or butter, but intangible assets such as scientific know-how and brand equity, superior management skills and quality systems, as well as access to a global network of supply chain relationships.

In the processing sector, a small number of substantial Irish and international companies now have a global reach; a larger group of small food companies mainly supply the Irish market; and a number of smaller (niche) high-tech companies supply high-end food products and services.

An interesting and important part of this pillar is the international involvement of Irish farmers and farm managers in developing grass-based animal production systems around the world. The value-added for Irish involvement in 'know-how' markets has increased significantly from its early roots in Saudi Arabia in the 1970s and 1980s and more recently, in New Zealand and North and South America.

Value-added Food Processing

This pillar in 2030 comprises firms that produce customised and innovative food ingredients supplied to global brand leaders in formulated foods and beverages and functional foods and bioactive constituents with validated health benefits. These firms operate at the boundary between food and medicine, and some are pioneers in applying nanotechnologies. The industry includes advanced food-processing and food-service firms with high added-value aimed at consumers and industrial clients - think of functional foods, bioactive constituents and 'cosmeceuticals' with validated health benefits, as well as customised food ingredients supplied to global brand leaders in formulated foods and beverages. These include some of Ireland's most competitive knowledge-economy companies and this pillar accounts for an increasingly important share of economic output and export activity.

This pillar is fast moving, innovative and international, continually adopting and improving the technologies used for production, processing, distribution and preparation. Supply chains are also constantly changing and considerable attention is given to intangibles such as patents, brands, provenance and traceability. This pillar is:

- **Knowledge-intensive** : it invests heavily in research and innovation, especially in areas such as health and nutrition, logistics, packaging and process technologies. It collaborates with a public research and innovation

infrastructure that is orientated towards the needs of the industry and can anticipate and respond rapidly to the consumer.

The Food Company of the Future

The major food companies of the world are repositioning themselves not as ‘food and beverage’ providers, but as providers of ‘health and nutrition’. Industrial dynamics are no longer driven simply by acquiring high value brands and developing distribution systems in new and emerging markets, but by establishing overseas research laboratories and acquiring science-based companies competent in healthcare, medical sciences, biotechnologies and clinical trials. The goal is to give consumers value foods that complement their lifestyle and provide health benefits as well as nutrition.

- **Diverse** : firms range from large research-performing companies to high-tech SMEs and they operate across the product spectrum from commodities to niche products and services, with many competing in the global markets for functional foods, ingredients and additives. Foreign multinationals attracted to Ireland by a knowledge-based foreign direct investment (FDI) agenda occupy an important place in the mix. Some operate in the pharmaceutical sector and form valuable partnerships with Irish food companies and research institutions. A few large firms, whose capacity for research and innovation sets them apart from their competitors, can supply knowledge-intensive products and services to markets in Europe, Russia, Africa, China, India and Southeast Asia.

Agri-environmental Products and Services

Farmers, as custodians of the countryside, deliver a wide range of important and socially valuable agri-environmental products and services in 2030. These include protection of clean water, provision of clean air, protection of the biodiversity of species and habitats, preservation of archaeological heritage and provision of recreational access



Agri-environmental products and services such as tourism amenities and landscapes will be an important commodity in 2030.

to the countryside. Other less obvious agri-environmental 'products' and services include: prevention of land abandonment, maintenance of genetic diversity of agricultural animals and plants, prevention of weeds and pests and mitigation of climate change.

Agri-food systems also provide security of food supply, animal welfare, maintenance of natural amenities, oversight of rural development, contribution to land use and spatial policy and support of tourism which, in some in rural areas, is the main source of income. The 'consumers' or beneficiaries of all of these products and services include the sectors that rely on them as inputs – the food industry in terms of a clean green image, tourism, etc. and the people of Ireland who rely on them for quality of life, whether they live in rural or urban areas, alongside those who visit for business or leisure and those who live close to our border.

In 2030, society is paying for these agri-environmental products and services, but also demanding greater accountability for their environmental effectiveness and economic efficiency. So, there is a significant need for differentiated research, advice and education, tailored to

the needs of the various farming systems and situations, so that they can maximise their competitiveness while being sustainable. Intensive systems aim to comply with the 2030 equivalent of good farming practice, but rely on the open market for most of their income and receive limited payments for providing only modest levels of agri-environmental benefits. In contrast, other farming systems focus solely on providing agri-environmental benefits.

The production of these products and services is now so important that it has become an important area of innovation. These 'goods' are produced in greater quantities and at cheaper costs. The science and technology needed to do this are in place and are being adopted.

Energy and Bio-processing

This pillar encompasses the forestry sector, tillage farmers and resource managers who produce feedstock for energy and bioprocessing. It is, still in 2030, a relatively young sector and its growth will reflect the level of our national ambition and policy initiatives. In 2030, Ireland has achieved its target of 17% of land use in forestry, and forestry provides many new and innovative products, such as fuel, fibre, cellulose–



The Farm of the Future?

Insulin injections for Type 1 diabetes could become a thing of the past, thanks to a Canadian company called Sembiosys. It farms 400ha. of sunflower plants to extract valuable insulin-bearing oils from the seeds. The plants were engineered to produce human insulin embedded in oily nano-structures so that, when ingested, the insulin is protected from harsh stomach acids until it can reach the lower intestine where it is absorbed. This paves the way for a new approach to drug delivery. The farm has its own processing plant and provides products for human and animal therapeutics and for the cosmetics industry. Venture-backed and quoted on the stock-exchange, it is one example of what farming could look like in 2030.



Green grows the feedstock: by 2030, we could be growing a significant percentage of our bioenergy and bio-chemicals, in addition to feed crops and fodder.

based chemicals and engineered wood products. These contribute significantly to meeting our GHG emission targets through carbon sequestration. In certain areas, they also provide public value by maintaining ecosystems, protecting watercourses and enhancing biodiversity.

Forestry generates significant employment, aids rural sustainability and plays an important role in meeting local, sustainable, affordable energy requirements. Forestry also of course plays a critical role in carbon sequestration.

The energy and bio-chemicals sector has evolved considerably in the last 20 years, fostered by national policies and linked to new markets for energy products, high-value chemicals and plant fibres. This sector is characterised by the importance it places on knowledge and by the high level of risk associated, not only with the science, but also with the emergence of entirely new markets.

An important factor for success has been the innovative use of crops grown for multiple purposes, including seeds for

food, fibres for clothes and extracts for chemicals. The current portfolio of high-value industrial products from plants includes ethanol, biodegradable plastic, plant sterols, nutraceuticals, xylose, cellulose, levulinic acid and novel plant oils.

Conclusion

In the knowledge-based bioeconomy of 2030, the traditional areas of food production and processing and value-added food processing continue to play a prominent role and make a significant contribution. The relative importance of agri-environmental products and services and the energy and bio-processing sector depend, to a large extent, on policy reforms and external factors. The relative contributions of these four pillars determine the ongoing research priorities. Business opportunities and scientific challenges are linked to concerns for health and nutrition, the convergence of food and pharmaceuticals, the management of climate change and the transition to a sustainable post-petroleum economy.



The Not-so-humble Potato

Demand for potatoes and for ingredients derived from potatoes is expected to grow as cereal prices soar, according to the United Nations' FAO. About 80% of the potato crop can be used for human consumption, significantly more than for cereals such as maize and wheat. The FAO is therefore promoting the potato as an efficient crop that can improve food security in developing countries. Ayeba, a Dutch potato starch specialist, created a new company called Solanic in 2007 to develop and market added-value non-starch ingredients derived from potatoes. Solanic will supply vegetable-derived proteins to the food industry as an alternative to animal proteins. When opening the new factory, the Dutch Secretary of State for Agriculture, Nature and Food Quality drew attention to the company's green credentials saying: "Solanic fits perfectly within the image of a bio-based economy. An image of a green economy in which national and international companies use green raw materials to manufacture non-food as well as food applications."



04 How will Ireland Respond?

Historically, Ireland's economic development relied on attracting foreign direct investment. Competition from developing countries means we now need new strategies and policies. One such strategy is to create a knowledge-based bioeconomy with innovation at its core. Here we outline the national strategies and the challenges and implications for the agri-food sector, for farms, firms and policymakers and for Teagasc.

Ireland's economic strategy over the past four decades was to attract mobile foreign investment through various incentives. This policy was very successful: Ireland is now home to many key international companies in a range of industries. The strategy helped nurture the 'Celtic tiger'. However, the competition for FDI is becoming more intense, with new countries such as Puerto Rico adopting the Irish model and offering attractive incentives and significantly, a lower cost base. Even within the enlarged EU, Ireland now competes for inward investment against lower-cost countries with well-educated workforces such as Poland and Lithuania. Ireland continues to attract FDI, but this must increasingly focus on knowledge-intensive, high value-added activities. In parallel, indigenous companies must increase their research activities and we must conduct research and generate knowledge relevant to the Irish situation. Our industrial policy has to embrace the potential of the agri-food and broader bio-based sectors as a core element of Ireland's knowledge-based economy. Continuous investment in research and

innovation is crucial to achieving this goal.

To create an Irish bioeconomy by 2030 will mean improving the efficiency of existing agricultural production systems, enhancing their environmental performance, particularly in terms of their impact on climate change, and exploring whole new sectors by exploiting bio-resources that have so far been overlooked and untapped. This will be a knowledge-intensive economy, where science leads to technology that opens up new market opportunities and that is driven by the needs of product and process innovation.

This strategy accords with national and EU goals for developing sustainable knowledge-based economies and aligns with the shift in Irish industrial policy from a high dependence on FDI to developing an indigenous capacity to innovate, particularly around bio-resources. It also recognises the prime importance of pursuing new markets and promoting economic growth in an increasingly competitive and open international market environment.

Key Messages

For the sector : promote knowledge generation and dissemination, learning and problem solving. Policy drivers at EU and national level will create new markets and opportunities.

For farms, firms and policymakers : they must be able to adapt quickly to changing circumstances, generate added-value and support innovation.

For Teagasc : the agency must address the new challenges and needs facing the Irish agri-food knowledge system.

Bioeconomy Potential

Bio-industries are already a significant part of the Irish economy and they have the potential to become even more important. The food and drink industry alone, for example, has a gross annual output of nearly €20bn, but this could double to €40bn by 2030. In global terms, the potential is vast: the OECD estimates that world primary energy demand will rise by almost 60% between now and 2030 and bioenergy resources could provide 50% of this by the next century.⁷ The International Energy Agency (IEA) predicts that biofuels' share of the global transport fuel market could rise from 1% now to at least 7% by 2030.⁸ The FAO predicts a 1.5% annual growth to 2030 for agricultural products globally, with higher growth in developing countries for meat, milk and



Self-milking systems for dairy cows: just one of the new techniques already helping to reduce labour and costs and improve productivity.

milk products.⁹ Developed countries will see greater demand for personalised nutrition and value-added foods with health attributes.

The seven drivers of change in the bioeconomy (Chapter 2) promise new and unprecedented opportunities for Ireland to benefit from its bio-resources well into the 21st century. The area under crop production, for example, could be expanded to displace imports of animal feed and provide crops for energy and other industrial purposes. Teagasc estimates that, in the right circumstances, the area devoted to tillage and energy crops could increase by 40% in 2020 from the current 330,000 ha. In dairying, Teagasc projects that any increase in EU milk quota between now and 2015 will be taken up by the Irish dairy industry: production could grow through increases in cow numbers (replacing beef animals on dairy farms with dairy cattle), stocking rate and milk yield per cow and by adopting modern technology such as genetics and labour saving practices.

Plant products will replace many of the petrochemicals currently used in manufactured goods, a shift that should

benefit companies in several sectors, including energy, fine chemicals, pharmaceuticals, plastics and packaging. There will be scope to license new technologies and for investment in and access to alternative raw materials. These trends will radically affect farming, linking it to other industrial sectors and further integrating the rural economy with the new industries. This should generate jobs and export-led growth from existing and new Irish businesses.

Policy changes at EU and national level are already helping to create new markets and new business opportunities. EU initiatives to encourage renewable energy, for instance the Biomass Action Plan, set out the ambitious goal of deriving 20% of energy from renewables by 2020, including 10% of all transport fuel.¹⁰ In Ireland, the Bioenergy Action Plan and the White Paper on energy also set ambitious targets for renewable use in the electricity, transport and heat sectors.¹¹ A key factor for success will be to develop second and later generation biofuels that use ligno-cellulosic biomass feedstock and do not adversely affect food supplies and the land available for food crops.

By 2030, 10-20% of chemicals could come from biological sources and advanced biocatalytic processes

Clearly, this sector is a major investment opportunity with great potential for new jobs. The opportunity for Ireland is to participate in this wave of investment, transfer technologies to existing firms, create new innovative companies capable of attracting international capital and attract investment by large biofuel, bio-processing and energy companies.

The Challenges

Innovation, whether in new markets, new technologies, or new processes, is the foundation for growth of the Irish bioeconomy. The challenge is to drive the transformation of the agri-food sector into a knowledge-based bioeconomy that fully embraces new technologies to create value-added outputs in an environmentally sustainable manner.

The high costs of land, labour and inputs are a major obstacle for producers. Land prices and land availability are a particular problem for grass-based production systems. Land prices are controlled by the market and cannot be influenced by policy, while land availability can be subject to conflicting demands from other sectors, notably the construction industry and amenity uses. However, it should be possible to design and implement policies that would help to make more land available.

One of the challenges for new and emerging business sectors is developing supply chain or value chain partnerships, since new products and services cannot be developed in

isolation and require collaboration with other partners in the supply chain. In the case of biofuels, for example, a farmer will not grow feedstock unless companies are ready to buy and process it; and processing is not viable unless there is a market for biofuels. Producers, processors and adventurous consumers need to co-operate to make things happen and this is true whatever the new sector. Those who provide technical expertise and perform contract research are important components of modern supply chains. The value created in the network is increasingly tied up in intangibles such as intellectual property and other forms of know-how.

Government policy now acknowledges the vital role that research, development and innovation play in maintaining Ireland's competitiveness and the country has invested hugely in the area under the previous and current national development plans. Considerable success has been achieved as a result of this investment. Agriculture and food will continue to play a significant role, but their competitiveness depends on their ability to develop as knowledge-based industries, because the bioeconomy is even more dependent on discovering and applying new knowledge. Science, technology and innovation (STI) will enable agriculture to expand beyond food and feed to include bio-materials, bio-energy and bio-pharmaceuticals, creating products that can compete on the basis of quality, safety and environmental attributes as well as taste and convenience in the face of rapidly evolving consumer preferences.

The Government's STI strategy envisages Ireland in 2013 as being: "Internationally renowned for the excellence of its research, and. . . to the forefront in generating and using new knowledge for economic and social progress, within an innovation driven culture." The strategy outlines the steps needed to achieve this: key human capital investments across education and industry, mechanisms to translate knowledge into jobs and growth, and agendas for public sector research in agriculture, health, environment and natural resources. It also addresses the vital international and all-island dimensions of research and innovation and provides the necessary resources in the National Development Plan (2007- 2013).¹²

In 2030 . . .

- There could be six million people living in the Republic of Ireland
- Over 40% of the Irish population will live in the 'Greater Dublin Area' alone
- Turnover in the food and drink industry may have doubled to €40 billion
- Agriculture will adapt to early climate change impacts
- 10-20% of chemicals may be derived from biological sources
- More crops will be grown for energy and industrial processes.

Teagasc is developing a number of world-class research centres

This STI strategy recognises the development of a knowledge economy as 'one of the key challenges and opportunities facing Ireland'. This will require a greater contribution from public research and a huge shift in the quality and quantity of research undertaken by the private sector. Despite having one of the strongest growth rates in business R&D, business expenditure on research as a percentage of economic activity is static at 0.77% of GDP. Despite unprecedented State investment in STI in recent years, and a further €8.2bn planned under the NDP,¹³ Ireland is far from the targeted 2.5% of GDP expenditure on R&D by 2010.¹⁴ (Total R&D spending in Ireland increased from 1.35% of GNP in 2002 to 1.43% in 2004, below the EU25 average of 1.85% and the OECD average of 2.24%¹⁵).

The Implications

The implications for Teagasc are sizeable, not least because the agency's research programme spans the entire agri-food chain from farm production to food processing. Already,

Teagasc is developing a number of 'centres of excellence' - world-class facilities that will enhance its scientific capacity and its access to networks of excellence around the world. The publicly-funded agri-food research system in Ireland is well integrated and the various research providers act in a collaborative manner. Through its advisory and training services, Teagasc also plays a crucial role in transferring the research results to industry.

There are also significant implications for the Irish agri-food industry. Like other indigenous sectors, it must grow its research and development capability and improve its capacity to absorb new technologies. The current level of expenditure on research is low and the sector spends about 0.2-0.3% of sales on research. A small number of large Irish-owned companies have extensive research activities, but much of this takes place outside Ireland. Attracting this back to Ireland and attracting bio-based FDI relies on having adequate support and capabilities for research here.



The new Plant Biosciences research and innovation centre at Teagasc, Oak Park.



Biotechnology Centre at Moorepark Food Research Centre

This presents a major new challenge to the Irish agri-food knowledge system, of which Teagasc is a key part. The system needs to build the capacity to adapt quickly to changing circumstances, generate greater economic value and support innovation that will allow Irish firms to compete at the global level. Reform of the Irish innovation system is essential to ensure that it is more efficient and responsive. This will entail more networking across disciplines, more emphasis on responding to market needs, more emphasis on scientific partnerships across the supply chain, and above all, new structures and a new emphasis on the rapid transfer of knowledge to end users.



05 Positioning Teagasc for a New Era

By 2030 the bioeconomy will have become a central sector of the Irish economy, meeting the increased demand for food, bioenergy and bio-processing of raw materials. The focus of Teagasc activities will have shifted to this broader bioeconomy and its role in the transfer of knowledge to farms and firms will be well established. The hallmark of the organisation will be the quality of its knowledge and the effectiveness of its innovation-support mechanisms.

Teagasc's role into the future will be to support the agri-food sector and wider bioeconomy by fostering science-based innovation on farms and in firms. It is farms and firms that will innovate and hence bear much of the risks involved. Teagasc, together with other relevant State agencies and its stakeholders, will support the transformation of knowledge into value for the benefit of the economy and society.

Innovation constitutes a wide spectrum of activity, ranging from the development of new products and processes that require a strong science base to activities that are less scientific. Teagasc's role places it at the point of the innovation

Key Messages

- Teagasc must become more innovative to keep pace.
- Teagasc's role is to promote science-based innovation within the agri-food sector of the bioeconomy.
- Excellence in supporting innovation will depend on building organisational capabilities in leadership, partnership and accountability.
- Teagasc will establish a new technology transfer service for food companies.
- Teagasc will adopt the most innovative techniques to ensure effective technology transfer.
- Teagasc will strengthen its investment in biosciences and enhance the depth of its scientific effort.
- Teagasc will continue to upgrade its educational programmes to the highest international standards.

Mission Statement

Teagasc's mission, identified by the Foresight exercise, is:

To support science-based innovation in the agri-food sector and the broader bioeconomy that will underpin profitability, competitiveness and sustainability.

spectrum that is most demanding in terms of knowledge transfer. This is because of the high level of investment and risk involved and because farms and firms may lack the ability to adequately absorb the scientific knowledge they need to innovate. Success for Teagasc in this role will be to enable our client sectors to build a sustainable rural economy and to contribute to the maximum extent possible to sustainable national economic development. All of Teagasc's activities are directed at underpinning and supporting this objective.

This is not a new role. For Teagasc and its predecessors, An Foras Talúntais and ACOT, What is new, however, is the pace of change, the intensity of advanced knowledge needs, the urgency of challenges related to food, energy and climate security and the need to respond to challenges and opportunities faster than ever before. Now, Teagasc itself must become more innovative to keep pace. The key to achieving this will be to ensure the continued upgrading of our scientific capabilities, better integration of our research, advisory and education services so as to transfer knowledge more effectively together with more focused stakeholder participation, better priority setting and more flexible resource allocation.

Traditional approaches to science-based innovation support

'It is neither the strongest species that survive, nor the most intelligent, but those that are best prepared for change'

Charles Darwin

focus on creating or discovering knowledge that is adapted and filtered from national and international sources and passed on to the client sectors through a dissemination or 'knowledge transfer' process. This approach was very linear in nature (Figure 2). New approaches are now required. Farms and firms have ready access to knowledge from around the world and this, coupled with the need for co-operation on complex issues, creates the need for a more networked and interactive process, especially when clients themselves contribute knowledge to the system. In this case, the ideal relationship between Teagasc and its partners and stakeholders should look more like that shown on Figure 3.

Education, the internet, low-cost travel and greater independence in the operation of universities and research institutes have all played a role in transforming the access to knowledge in recent years. We are moving from a linear supply-driven system of innovation support to one that is more open and interactive. Public innovation-support

Internationally Unique

Teagasc combines research, advisory and education services into an integrated agency and serves farms and firms, government and society. There is no equivalent service internationally. Teagasc employs nearly 1,400 staff in 100 locations throughout Ireland with an annual operating budget of over €170 million. It has 200 research scientists and 210 research technicians at nine dedicated centres; 570 advisors, regional specialists and education staff at regional, county and local offices; and eight colleges and local training centres. Every year it helps nearly 50,000 client farmers to improve their business. Teagasc is also a respected brand that can reach into every aspect of the rural economy and the countryside. This puts Ireland in an excellent position to make the transition to a knowledge-based bioeconomy, with Teagasc playing a key role. Teagasc will use its knowledge base to compete for international research contracts and will increasingly participate in supporting Ireland's' growing internationally traded services sector.

agencies such as Teagasc need to re-examine their role in this new context. Our clients are becoming more demanding and sophisticated in the support they require and Teagasc must respond in a way that is timely and relevant and clearly adds value.

There are three strands to supporting science-based innovation: creating and acquiring accumulated knowledge, transferring that knowledge to client groups and helping those clients to absorb the new knowledge. Teagasc is unique in combining all of these functions in a single institution (Figure 4). All three require constant attention, however and if even one is missing, or operating less than effectively, the quality of the innovation support service will suffer.

In a world with many knowledge providers and where access to innovation is increasingly becoming more open, Teagasc needs to ensure that its strategic focus adds value to its target sectors. Teagasc believes that by continuing to focus on linking all of its activities to national STI priorities and by steadfastly adhering to the transfer of its knowledge resources for the benefit of farmers and processing firms as its primary aim, this will form a unique brand and identity in the innovation-support space.

Vision, Leadership, Partnership, Governance

Teagasc's vision is to provide excellent science-based innovation support of international standing to the agri-food sector and the wider bioeconomy.

To realise this vision, Teagasc itself must innovate. In particular, the organisation will develop and maintain the right skill-mix and adapt its structures and delivery mechanisms to the evolving needs of its clients. Excellence in providing innovation support will depend on three key organisational capabilities:

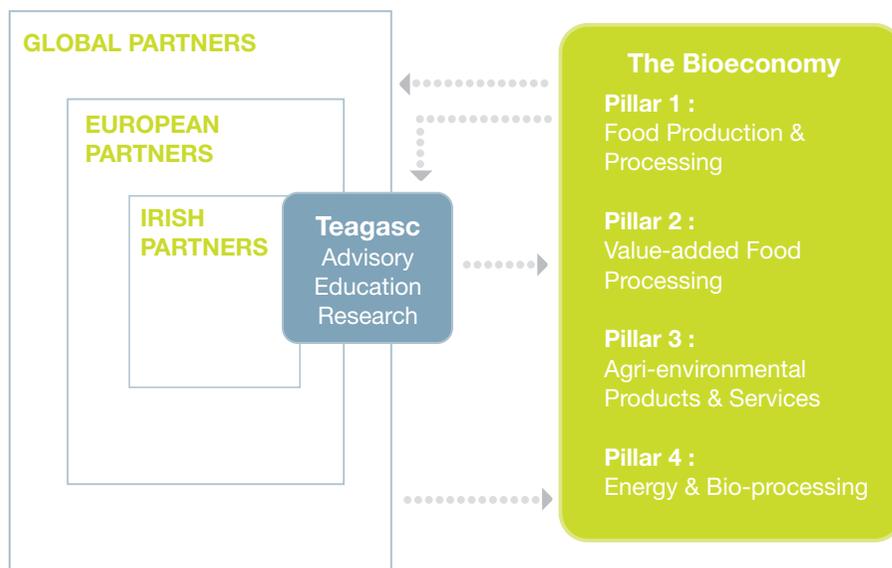
- Leadership
- Partnership
- Accountability and governance.

Leadership : proactive leadership is essential, particularly given the challenges and opportunities outlined in previous

Figure 2 : The traditional model of knowledge transfer



Figure 3 : The 'new' model of knowledge transfer



chapters. This is true for many sectors, not least in the case of the dairy industry that faces the prospect of expansion with the abolition of quotas by 2015. But leadership is especially needed for the new and emerging sectors such as biofuels and bio-processing. Teagasc will identify and address leadership gaps following from structured dialogues intended

to understand the innovation challenges of the sector and how they can be addressed.

The legitimacy of our leadership role will depend on the excellence and scope of our activities. To secure this, Teagasc requires:

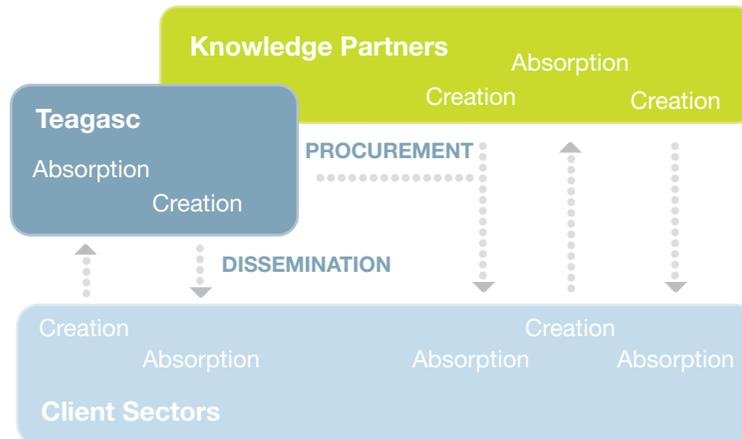
- A critical level of investment in high-quality scientific research. This is of direct importance as a service to certain clients and indirectly important in providing access to global knowledge networks;
- Support for the procurement of knowledge for or by clients and not just the creation of knowledge from in-house research;
- An openness and responsiveness towards future opportunities and challenges;
- An expanded skill-set, including new science skills and skills in areas such as ‘knowledge reconnaissance,’ ‘knowledge procurement’ and knowledge transfer adapted both to the needs of SMEs and to new and emerging sectors such as bio-materials;
- A commitment to national and international collaboration and, in particular, to play our full role in developing the European Research Area; and

- More flexible human resource policies, affording greater internal mobility within the organisation, providing opportunities for continual professional development, as well as performance-based incentive schemes to motivate and reward staff.

Partnership : complex challenges now face agriculture, food and other bioeconomy sectors that can be addressed only on the basis of active and deep-rooted collaboration among all interested parties. Teagasc must, therefore, develop strategic partnerships independently of project and programme funding cycles. This will be hard work and require resources and a strong commitment to collaboration, especially at the inter-agency level. It is also linked to the leadership role that Teagasc may assume on specific issues.

Some of these partnerships will be constructed around value-chain platforms that embrace key bioeconomy development themes such as rural, dairy or agri-environment development. The main task for these partnerships is to advise on rolling ‘innovation agendas’ and on how these should be supported and implemented. For this task, Teagasc will continue to draw extensively on the ‘commodity advisory groups’ established in recent years.

Figure 4 : Innovation support elements



Some partnerships will have a more narrow focus and bring partners together around technologies of mutual interest. Teagasc, for instance, will be proactive in assembling inter-institutional teams in bidding for competitive public research funding and will use these to build critical mass in priority areas; the organisation will also establish international partnerships and strategic alliances where necessary. Teagasc's unique strengths in knowledge creation and transfer are a vital asset for enabling the science-industry linkages that will be critical for successful innovation in the future.

Other forms of partnership may be required for specific projects or programmes. Depending on the motivation, partners might include clients or their representatives, stakeholders and other relevant agents such as universities, research institutes and funding bodies.

Accountability and governance : Teagasc's relevance as a central support player for science-based innovation in the bioeconomy cannot be taken for granted as we move into the future. Our activities are substantially funded by direct State subvention and this subvention must rightly be reviewed from time to time to ensure that the State is generating value for money. The rationale for a publicly-funded knowledge generation, transfer and education organisation such as Teagasc is that, without State support, the private sector would not undertake these activities. As a consequence, the benefits that might accrue from commercial use of knowledge would not be realised. Therefore, all of Teagasc's activities must pass a double-hurdle test. First it is necessary, to establish that, in the absence of State support, the activities would not be undertaken by the private sector. This ensures that scarce taxpayer resources are not diverted needlessly for the benefit of private-sector players. Second, assuming that this hurdle is surmounted, we must ensure that the activities in question generate the maximum possible expected value for our client sectors, namely farmers and food companies and the wider community. These are stringent requirements.

As we look at the likely trends and prospects for the bioeconomy, we can envisage that some activities which

Teagasc currently undertakes and which may pass the first hurdle now, may not do so in the future. For instance, as farmers become ever more specific in their requirements for usable knowledge, many of them may seek to acquire this knowledge from the private sector. Indeed, a trend could develop whereby more and more highly specialised knowledge becomes embedded into inputs that can be purchased directly by farmers and firms without any intermediaries. We may also see a drift towards market-specific requirements on the part of processing firms. As this sector becomes more concentrated, the justification for State subvention could change or weaken, while firms themselves will increasingly want knowledge tailored to their specific circumstances.

The second hurdle of the test is to ensure that Teagasc's activities are relevant and prioritised in the context of a partnership process that seeks to maximise the potential creation of value for the bioeconomy. The most effective means of ensuring that Teagasc passes this test is to have appropriately designed internal and external monitoring and evaluation systems in place.

Integration

Teagasc will fully exploit its unique organisational strength by further integrating its research, advisory and education activities. This will require human resource reform, such as removing barriers that restrict movement of professional staff between areas and programmes. The current Teagasc HR Strategy envisages a common entry professional grade and cross-stream access to professional posts on a competency basis, regardless of an individual's current categorisation.

Improved programme integration is a second priority. The main objective is to create a shared sense of responsibility and ownership within the organisation for innovation support. This will result in a shift towards greater programme depth and more measurable programme delivery and impact in terms of value added in the economy. External integration with key supply chain participants and other development agencies will also be strengthened to enhance Teagasc's relevance and utility to its clients.

A key integration strategy will be the re-designation of the existing applied research centres as 'Research and Innovation Centres'. These will be devoted to creating applied knowledge and developing systems relevant to stakeholders. They will have direct links to our knowledge transfer functions.

Therefore, there will be a significant focus on integration to provide the science-based innovation support required by our clients. This will involve more theme-based and time-limited multidisciplinary projects and sub-programmes. These will be identified, developed and delivered with the involvement of our stakeholders. An integrated evaluation process will ensure ongoing organisational learning. The integration process will ensure Teagasc becomes more agile, flexible and proactive at a time when continuous change will be the accepted norm. The main activities of the integrated organisation will continue to focus on knowledge generation, procurement, transfer and education.

Knowledge Generation

As a mission-oriented organisation, Teagasc will continue to ensure that the main focus of its research is on the rapid delivery of results with potential for economic and social impact. While retaining its strong capacity in applied research, the organisation will strengthen its capacity in key areas of fundamental research. There will be a new focus on and significant investment in the biosciences. This will ensure that agri-food research is fully competitive in the national STI programme and in the European Research Area. The organisation has already started to invest significantly in the biosciences. Insights provided by this new bioscience capacity will feed directly into the organisation's traditional strengths in applied agricultural and food research and help to broaden the scope and impact of ongoing activities.

In 2005, a new initiative, the **Research Vision Programme**, was initiated. This set new priorities for the agriculture, rural and food research programmes, creating a research strategy that will expand the resources devoted to emerging technologies and help develop world-class competence in selected key areas of animal, crop and food bioscience, energy, environment and rural economics. The investment in

the biosciences, social sciences and new technologies will continue.

A major new strategic initiative will be the establishment of a co-ordinated Grassland Research Programme (See Panel). This will build on and fully integrate the existing grass and forage research being conducted at a number of Teagasc centres and will link with other grassland research teams in Ireland and elsewhere.

One of the aims of the knowledge generation and procurement, or research activity, is to build critical mass through the effective deployment of research staff in key scientific programmes and through national and international research partnerships. We will continue to compete strongly for internationally-funded research contracts and we will play our part in growing Ireland's internationally traded services economy through greater deployment of our skills, expertise and technologies outside of Ireland.

An important consequence of this strategy will be to enhance Teagasc's potential to create intellectual property (IP), notably in bioscience research. We recognise the importance of IP creation and will take the necessary steps to ensure that we discharge our public responsibility in this area.

Knowledge Transfer

Teagasc structures will be reconfigured as required to ensure that the knowledge transfer function is as seamless and effective as possible for our farming and food industry clients.

Farm-based transfer : Teagasc has a long and successful tradition in the transfer of knowledge to the primary agricultural sector. It has recently re-structured its advisory services to allow greater specialisation and distinguishes between pure 'knowledge transfer' activities and 'farm-scheme support' activities. The priority for the next few years will be to ensure that this re-structured service is 'bedded-in' and can transfer knowledge quickly and effectively to our farmer clients.

Grassland Programme

Our temperate climate and fertile soils give Ireland a unique international competitive advantage in producing high-quality agricultural products from grass. Permanent grassland accounts for almost 80% of land use in Ireland. This new research initiative in grassland science will provide the technologies to further exploit animal production from pasture, both economically and sustainably.

Key challenges : increase animal performance per hectare of grassland by improving pasture growth, grass quality and intake characteristics. Specific objectives will include producing grass with higher growth rates and better quality over a longer growing season; increased animal intake and feed conversion efficiency; and increased nutrient use efficiency. A multi-disciplinary approach, bringing together grass physiologists, agronomists, plant breeders, animal nutritionists and environmental scientists, will be essential.

Technology requirements : plant and animal scientists will collaborate to gain an increased

understanding of the inter-relationships governing intake and utilisation at the plant/animal interface. Plant physiologists and morphologists will work to create a high-quality feed with high animal intake characteristics. Rumen nutritionists will define the effect of nutrient supply on animal performance and product quality within grazing systems and develop systems where more ingested nutrients are absorbed and converted to meat and milk. Breeding technologies (including molecular techniques) will be required to produce new grass and clover varieties with superior grass growth and quality traits for animal performance.

Benefits : the enhanced grassland research programme will provide the technologies to best address the key challenges facing Irish milk and meat producers and help develop and expand their businesses and enhance the green image and marketing potential of Irish livestock products internationally. This programme will also provide critical mass in grazing science to position Teagasc as the leading international authority on pasture-based systems of animal production.



Grass provides Ireland with a competitive advantage.

Education will produce the bioeconomy leaders of the future

For the foreseeable future, a substantial part of our advisory activity will be devoted to the vital area of ‘farm-scheme support’. This service must be constantly monitored and reviewed to ensure that its delivery is efficient and effective. It is critical that the delivery of this service in no way impairs our ‘knowledge transfer’ and development role, especially through pressures on scarce resources at the local level. Over the next few years, therefore, Teagasc will, following consultation and negotiation, explore the feasibility of centralising the delivery of its cost-recovery services (such as planning services for environmental and development schemes, analytical services and international consultancy, amongst others).

The key strategy is to provide effective knowledge transfer to as many people as possible, through a range of services and to meet the diverse knowledge and information needs of our customers and stakeholders. This will include:

- Continuing to research and employ the latest available technology transfer techniques;
- Developing and adopting new information and communication technologies (ICTs) to improve the efficiency of knowledge transfer and innovation support services. These include technologies for automated data capture and analysis, benchmarking and modelling and forecasting for improved decision support to farmers;
- Providing improved direction, relevance and feedback on knowledge transfer and innovation support services through a network of partnerships, joint industry programmes, technology platforms and commodity teams operating at national and local level; and
- Packaging and marketing differentiated knowledge transfer and innovation support services so as to provide customised technologies relevant to the diverse needs and circumstances of clients.

Food industry transfer : Teagasc recognises that the most productive recipients for much of its front-edge food research information are the top research-performing food companies and it considers that effective linkages with these companies in knowledge partnerships and technology transfer are

essential to its mission to drive the knowledge economy. Among such companies are large indigenous food firms and companies contributing to the Irish economy through foreign direct investment. Engagement with the top companies in an interactive and networked manner will greatly enhance Teagasc’s effectiveness, since it provides access to leading-edge information and it enables the benchmarking of Teagasc’s own competencies and, most significantly, can nucleate linkages in research-based innovation between indigenous companies and leading multinationals. The latter will be particularly important in achieving the ambitious objectives of the Irish food industry in functional foods development.

We recognise the international dimension of research and innovation, both in relation to public research linkages and to knowledge acquisition by food companies and view this as both a challenge and an opportunity for the organisation’s own future development. Teagasc will aim for international standards of performance and reputation in its food centres and for international recognition as a centre of excellence in research and innovation support.

Education

Teagasc will contribute to achieving the goals of the Lisbon and Copenhagen Declarations by ensuring that its education programmes are continually upgraded to the highest international standards. It is education that will produce the bioeconomy leaders of the future. Implementing the recent review of our education and training service will ensure that the programmes are student-centred, based on a platform of innovation and excellence and respond to the need for a competitive bioeconomy. The recent review of colleges has identified a need to ensure critical mass within our college network comprising staff, students and facilities ensure a critical mass of staff, students and facilities on a par with the best in the sector.

Our strategy will be to significantly integrate our education activities with our knowledge generation, procurement and transfer activities. College farms will be used to quantify the benefits of and demonstrate state-of-the-art production technologies through involvement in our new BETTER (business, environment and technology through training, extension and research) farm programme.

Our educational programme strategy will include

- Incorporating management practices and technologies on the home farm, supervised project work and discussion groups: linkages with higher level education institutions will be extended, so that students can progress from certificate to honours degree and beyond.
- Being the main provider of further education for school leavers in agriculture, horticulture, forestry and equine studies: we will place an increased emphasis on advanced courses and on progressing to higher-level programmes in these areas.
- Collaborating with other higher-level educational service providers, Teagasc will provide the leadership to develop high-quality, relevant and applied higher-level educational programmes: Teagasc will embark on new 'business and technology' degree programmes, commencing with a dairying programme, in collaboration with university partners. This programme and similar initiatives in the

future will provide future generations of farmers with the entrepreneurial skills and international experience to participate in competitive and sustainable farming systems.

Foresight Implementation Unit : Teagasc has established a Foresight Implementation Unit attached to the Office of the Director to oversee the implementation of the Foresight report. This unit will have responsibility for monitoring delivery on the Teagasc 2030 report and its first task is to prepare an action plan detailing the initial steps needed in realising the Teagasc 2030 vision. It will also have a more general role to develop a culture of continuous foresight throughout the organisation, as well as to provide horizon-scanning and knowledge-reconnaissance. It may also have a role in addressing issues related to the public perception of bio-economic issues, consumer confidence and cultural change.

Resources Implications

Teagasc currently has a staff of approximately 1,400 full-time equivalent posts across all research, administration, advisory



Teagasc trains 200 post-graduates each year.

Teagasc is investing 27m euro in its programmes

and other grades. We have had some flexibility to move posts between categories on a non-cost-increasing basis, but this flexibility needs to be formalised and extended, and we need the flexibility to determine the future grade structure and numbers within grades subject to the overall numbers and cost limits. In this way, we can ensure that promotion for professional staff is aligned to the contribution they make to knowledge generation, dissemination and absorption.

Teagasc also has a substantial network of research centres, colleges and offices throughout the country. (Over the past six years many small research and office locations have been sold). The organisation is currently engaged in a substantial capital investment programme, investing some €27m to create five 'centres of excellence' in animal bioscience, crops bioscience, environmental science, rural research and food

research. A further €13m is being invested to improve college facilities and offices. Funding for this has come from the sale of land for road construction and industrial development. To maintain our capacity to carry out research and education to the highest standards, significant further investment will be needed in the near future. In addition to the annual capital grant-in-aid required to maintain and update the agency's existing capital infrastructure, Teagasc will carry out a thorough examination of its resources and seek to identify ways of releasing the capital required for major projects in the future.

As a public-sector organisation, Teagasc will continue to operate as efficiently and effectively as possible and provide value for money. In this regard, we will focus our science and innovation investments on the national priorities identified with stakeholders. We will ensure that our investments will achieve an appropriate balance between existing and new services, between existing and new markets and products and between grant-aid and competitive funding.

With these opportunities come challenges, however – how to put in place the necessary enablers, how best to structure our commercial, business and research environments and educational systems and how to facilitate the integrated, inter-disciplinary work that is essential if this bright future is to be achieved.

Innovation Linkages

Teagasc is already well advanced in its innovation linkages with leading food companies through its subsidiary company, Moorepark Technology Ltd. MTL, supported by the scientists of Moorepark Food Research Centre, has been involved in many successful product and process developments with food companies. An outstanding example of this and a model for innovation impact and for networking of foreign and domestic companies, is the alphasalac project. Alphasalac is a constituent of whey and represents 20% of total whey protein. Mother's milk is rich in alphasalac and, therefore, enrichment of infant formula with cows' milk-derived alphasalac was a desirable goal. The technology to produce alphasalac was developed by Moorepark scientists and subsequently, in a commissioned project involving the infant formula multinational Wyeth and an Irish dairy company, was developed to industrial scale using the pilot plant facilities of MTL. Alphasalac is now incorporated into Wyeth infant formula worldwide and is the most significant innovation of recent decades in the humanisation of infant formula.

The Knowledge Economy

The 'Knowledge Economy' refers to the emphasis on investment in 'Knowledge Capital' as the means to meeting the economy's long-term rate of economic growth.

In order for living standards to grow in all economies, a constant level of capital investment is required. Capital can take on many forms, such as, physical capital in the form of the plant and machinery; public capital in the form of infrastructure; human capital in the form of education, training and work experience embedded in a country's labour force; and 'knowledge capital', which refers to the accumulation of ideas in the form of scientific publications, patents etc. that enable new products and services to be developed or which outline new and more cost effective production systems. All forms of capital investment generate returns in terms of higher levels and rates of economic growth.

The focus on 'Knowledge Capital' (or the 'Knowledge Economy') in recent years derives from the realisation that much higher rates of return can be generated from investment in this type of capital.

The reason for the much higher anticipated rates of return from investment in 'Knowledge Capital' is due to its unique attributes. Once a piece of knowledge is generated and made available publicly, as a published scientific paper, it can then be used in a potentially infinite number of places at the same time. Moreover, the marginal cost of using this knowledge over and over again in different circumstances is virtually zero. No other forms of capital share these attributes. Consequentially, investment in 'knowledge capital' is likely to generate even higher rates of economic growth.

The returns to investment in the creation of 'knowledge capital' are exceptionally high in circumstances where the knowledge is publicly available. But this also implies that the private sector will tend to under-invest in this form of capital, because in general, it is difficult for it to fully appropriate the benefits. As a consequence, the State will need to invest in 'knowledge capital', either on its own or in the form of public-private partnerships, to ensure that the economy-wide returns that can accrue to investment of this type can be maximised.



Investment in 'knowledge capital' is likely to generate economic growth.



06 Linking with our Stakeholders :
Implementation 2008-2015

Previous chapters set out the Foresight vision for the agri-food sector and the wider bioeconomy for the next quarter of a century or so and a high-level description of how Teagasc will respond to the opportunities and challenges presented by these anticipated developments. Here, we present medium-term programmes of activity planned for the four pillars of the bioeconomy and outline new programme initiatives.

The next quarter century promises tremendous opportunities for the agri-food sector and rural economy. With these opportunities come challenges, however. In particular: how to put in place the necessary enablers, how best to structure our research, advisory and educational systems, how to facilitate the multi-disciplinary and collaborative work that is essential if this bright future is to be achieved and how Teagasc can build strong relationships with all its stakeholders. As important as the long-term vision is the medium-term plans that will lay the foundation for future success.

Arising from this, the new Teagasc medium-term strategic goals are to:

- 1: Focus research and technology transfer activities on national priorities agreed in consultation with stakeholders;
- 2: Enhance farm profitability and sector competitiveness through the development of innovative and sustainable production systems;
- 3: Be a leader in the provision of scientific and technical support to farmers and food companies in product development and in ensuring the safety of Irish food;
- 4: Support the development of new opportunities for agriculture and rural areas through leading the development of the knowledge-based bioeconomy;
- 5: Enhance the environmental performance of the bioeconomy and underpin its role in meeting national energy requirements and mitigating climate change effects;
- 6: Produce knowledge and know-how to support key national policies and decision making in relation to the rural environment, rural development, energy, climate change and food security; and
- 7: Build a responsive, flexible and accountable organisation that works in partnership with other organisations to meet the needs of our clients and stakeholders.

Connecting with Our Stakeholders

As an addition to our on-going strategy of using commodity groups, we will develop a new initiative based on technology platforms to enhance our connections with clients. The technology platforms will help us achieve our goals by:

- Contributing to a shared vision among participants;
- Generating the knowledge required to support innovation in specific theme areas;
- Impacting on a wide range of policies through improved dialogue among stakeholders;
- Reducing fragmentation of research and development efforts through partnerships with non-Teagasc stakeholders in the knowledge economy; and
- Mobilising public and private funding.

Key Messages

Teagasc will connect with its clients and stakeholders to ensure the knowledge and technologies available are transferred to support them to take advantage of the opportunities and address the significant challenges. To further strengthen linkages, we will establish technology platforms.

'As for the future, your task is not to foresee, but to enable it'

Antoine de Saint-Exupéry

The technology platforms will focus on the strategic questions identified by stakeholders and which can only be solved through acquiring and applying new technologies. Technology platforms operate by bringing stakeholders together to define medium-to-long-term research and technological objectives and set deadlines for their achievement. They are thematic and time-limited. They will play a key role in aligning Teagasc and national research priorities with the needs of the fast changing bioeconomy. Technology platforms encompass the whole economic value-chain, ensuring that knowledge generated through research is transformed into technologies and processes and ultimately, into marketable products and services.

The internal and external integration facilitated by technology platforms is the key to their success. They can operate in a virtual sense rather than as physical entities and fit with the proposed re-constitution of Teagasc research centers as Research and Innovation Centres. They emphasise that the Teagasc mission of providing support to science-based innovation embraces tasks that go beyond research, knowledge transfer and education, to include knowledge reconnaissance and procurement. Technology platforms will capitalise on and accommodate the recently restructured advisory service. They complement and facilitate modern approaches to programme design and evaluation with the formation of multidisciplinary teams. Significantly, they require the cohesive management of bioscience capabilities across Teagasc's various units and programmes.

Successful science-based innovation requires the involvement of the users of the scientific knowledge - professionals from farms to firms to policy-makers - to participate in developing programmes. This is already being addressed through commodity groups in areas such as dairy, drystock, crops and the environment. The operation and membership of these groups will be reviewed with a view to professionalising their activities.

The continued involvement of stakeholders from Government departments, State agencies, knowledge institutions, supply-chain organisations and the wider public, will be vital for the success of the commodity groups. The activity will be

strengthened by establishing 'area unit stakeholder teams' tasked with exploring local priorities in relation to innovation support and service delivery.

Teagasc will continue to develop medium-term programmes of activity that are relevant to the four pillars of the bioeconomy (see Chapter 3). These will be guided by our goals outlined above. The integrated programmes provide the foundation for developing and maintaining our connections with clients and stakeholders.

Food Production and Processing

The food production and processing pillar encompasses the farmers and growers who produce food for human and animal consumption, from meat and milk-based products to crops and vegetables, plus the processors engaged in adding value to those raw materials. Teagasc's long-term goal for the pillar is to provide support for science-based innovation so that it is internationally competitive, profitable, sustainable, maximises added value, contributes to long-term food security while providing attractive career opportunities for young entrants.

Teagasc recently produced 'Road Maps' setting out medium-term targets and technology requirements to 2015 for the six main agricultural sectors-dairy, beef, sheep, pigs, tillage and horticulture-and also for forestry. Each road map presents a succinct summary of the main market and policy issues and the environmental and land-use implications for the sector and outlines key targets, with a snapshot of how each sector is expected to look in 2015. The Road Maps are available for download from our website (www.teagasc.ie). Summaries of the shape and size of the sector, with some key targets, are presented for dairy, beef and sheep in Table 6.1 and for the pig and tillage sectors in Table 6.2.

Over the next number of years, Teagasc's programme for the production sector will continue to focus on livestock, crops, environment and rural economy, on the nutrition, breeding and health of animals and crops and on reducing environmental impacts, particularly with regard to water and air quality.

TABLE 6.1. : An extract from the Teagasc 2015 Road Maps for the dairy, beef and sheep sectors.

	Shape and Size of Sector	Key Targets
Dairy	<p>There will be 15,500 dairy farmers based on the recent trend of decline of 3% per annum.</p> <p>Dairy cow numbers will be 1.127m. – an increase of 65,000.</p> <p>National milk production will be 5,84m t - an increase of 12.5% fat adjusted.</p> <p>Average farm quota will be 376,775 kg.</p> <p>Average herd size will be 73 cows.</p>	<p>A margin/kg milk solids (MS) at €0.3/l (€/kg MS) of €2.32 for the average herd and €2.88 for top herds.</p> <p>A net margin (€/ha) of €1,658 for the average herd and €3,165 for the top herds.</p>
Beef	<p>There will 90,000 beef herds – a decrease of 10% and most will be in REPS</p> <p>Beef cow numbers will be 1.08m, a fall from the current 1.2m head.</p> <p>A net margin (€/ha) of €1,000 for top herds.</p>	<p>Suckler Beef A net margin of €310, €355 and €630 for beef farms stocked at the equivalent of 170, 210 and 235kg organic nitrogen/ha, respectively.</p> <p>Dairy Beef A net margin of €1,050 and €925 for top Continental x Friesian and Holstein-Friesian systems, respectively.</p>
Sheep	<p>The national flock will be 2.7m ewes – a decline of 10%.</p> <p>The lowland sector accounts for about 75% of the ewes and 85% of lamb carcass output.</p> <p>There will be approximately 29,000 flocks - a decline of about 12%.</p>	<p>Lowland Sector 1.5 lambs/ewe.</p> <p>Average stocking rate of 11.5 ewes/ha.</p> <p>Output of 17.5 lambs/ha (350kg lamb carcass).</p> <p>A gross margin of €1,000/ha at current prices and costs.</p> <p>Hill Sector 0.9 lambs/ewe.</p>

TABLE 6.2 : An extract from the Teagasc 2015 Road Maps for the pigs and tillage sectors.

	Shape and Size of Sector	Key Targets
Pigs	<p>The national pig herd will consist of 1.7m pigs, including 150,000 sows.</p> <p>Annual slaughterings will increase by 10% (3.6m pigs per annum).</p> <p>The number of production units will increase to 500, due to an increase in contract finishing.</p> <p>Employment, including associated industries, will amount to 7,000.</p>	<p>Sow productivity will increase from 21 to 24 pig/sow/year.</p> <p>Carcass weight will rise from 74kg to 80kg.</p> <p>Concern over boar taint may limit this.</p> <p>The current feed conversion efficiency of 2.47kg feed/ kg weight gain (weaning to slaughter) is targeted to improve to 2.3kg feed/ kg weight gain.</p>
Tillage	<p>The area devoted to tillage and energy crops is expected to increase by 13%.</p> <p>There will be 1,000 full-time tillage farmers, producing close to 60% of output.</p> <p>Most tillage farmers will be in REPS.</p> <p>Maize production will increase two-fold.</p>	<p>Spring barley yields to increase from 6.3 to 7.0t/ha.</p> <p>Winter wheat yields to increase from 9.3 to 10.2t/ha.</p> <p>50% of commercial growers using minimum tillage establishment techniques.</p>

Of concern are issues relating to animal and crop health, as they have substantial cost implications. Preventing the introduction of new pests and diseases is essential to maintaining our “clean green” image. The importance of crop and animal health to food supply security is emphasised when it is considered that only about 15 plant species and eight animal species supply 90% of the world’s food. The focus of activities in this area will be on breeding disease-resistant plants and animals; developing novel systems for managing and monitoring both plant and animal diseases and weeds; and improving client awareness and technology support.

The Programme will develop competencies in: animal genetics (including genomics); reproductive biology and

technologies; growth and development biology; animal disease diagnostics; forage improvement and forage biotechnology; animal and crop nutrition; soil chemical and biological processes; bioinformatics; mathematics and statistics; economic and social sciences.

The main message for farmers in all cases is that Teagasc will continue to improve and develop the technologies farmers need if they are to extract the maximum output of profitable, high quality and safe products while reducing environmental impacts. Achieving this aim will require high levels of innovation in all areas of production, from soil to farm gate. Success will depend on good planning and business management.

TABLE 6.3. : An extract from the Teagasc 2015 Road Map for the horticultural sector.

Shape and Size of Sector	Key Targets
<p>Increase in farm-gate output of approximately 30% to €390m.</p> <p>Continuation of consolidation, specialisation and capitalisation of enterprises.</p> <p>Anticipated 600-700 production units.</p>	<p>Mushrooms : target of 360kg/t phase III compost, increased use of system - built units and possible development of robotic picking.</p> <p>Fruit : adoption of protocols to improve quality and supply of a range of crops over maximum season, post-harvest techniques to extend shelf-life.</p> <p>Nursery stock : improved efficiency in controlling wastage and increasing crop turnover; new plants and added value products required.</p> <p>Vegetables : crop management and protocols will need to change with reduced pesticides; innovation in crops and vegetable products required.</p> <ul style="list-style-type: none"> • Full implementation of integrated pest management (IPM) across the sector. • Benchmarking of enterprises to improve labour efficiency. • Continued season extension and development of management protocols for new crops.

Measures to support food processors will reflect our belief that, in the medium-term at least, milk production will increase, beef output will remain relatively static and energy and commodity prices will remain higher than the historic levels. It will be set in the context of a commodity sector that achieves global competitiveness through efficient and sustainable processing incorporating scale consolidation, the most energy efficient technologies and maximum recycling of by-products. The sector is self-reliant in core process technologies for mass market products. We project an 80% increase in the output volume of dairy products focusing on milk powders, cheese and ingredients for infant formula. A further goal will be to develop a growing, profitable and sustainable food processing SME sector. Teagasc will undertake research that: underpins innovation and quality in

cheese, meat and specialised commodity products; promotes profitable utilisation of by-products; facilitates energy efficiencies in processing and in the supply chain to market; and ensures the highest standards of product safety.

The science needs of the programme will be to understand the molecular, micro structural and compositional factors that define the sensory characteristics of mass market dairy and meat products and downstream products, and that relate to the development of new process technologies aimed at energy saving. This will require research capability from genomics to processing to food formulation. There is also a need to develop the microbiological and analytical tools to control emerging biological and chemical hazards, including toxins.

Teagasc will establish an SME technology support service

Value-added Food Processing

Fast moving, innovative and international, this pillar is continually adopting and improving the technologies used for production, processing, preparation and distribution. Considerable attention is also given to intangibles such as patents, brands, provenance and traceability.

The main goal is to maximise value added through post-commodity market-led product innovation in food ingredients and consumer foods from the dairy, meat and cereal sectors. Dairy companies and specialised ingredient manufacturers will be innovative in the development and customisation of ingredients for formulated foods from a variety of dairy and non-dairy sources. The sector will provide leadership in functional food markets by developing bioactive ingredients and forming strategic alliances with research institutions and multinational food and pharma partners. The industry will respond to meet changing consumer needs in taste, convenience and health concerns and produce a more diverse range of dairy, meat, drink and cereal-based products for consumers around the world. A second goal will be to

control food-borne contaminants in the value chain based on the principles of quantitative risk assessment.

To support this sector, Teagasc will establish a clinical and bioscience platform for functional foods and food bioactives with validated health claims. We will also develop the chemical sciences and bio-processing technologies for discovery, isolation and delivery of food bioactives and conduct research to underpin the development of processed foods with reduced fat, salt and additives. Other initiatives will include market research on value-chain efficiency and consumer acceptability; research on ingredient functionality and product structure as related to food quality, shelf-life and sensory properties; and food safety research into microbiological and chemical residue threats to the food chain. There are many small-to-medium Irish firms in this sector, and they will be able to call on Teagasc's new SME technology support group for assistance in technology transfer.

Knowledge transfer will largely be accomplished by confidential mechanisms based on fair and open competition. An important role in the overall generation and transfer of knowledge will be played by the formation of consortia and strategic alliances involving industrial and academic partners. Intellectual property management will be prioritised and campus company formation will be pursued where this adds value to the knowledge management process.

The science needs of the programme will include food ultra-structural analysis, texture and sensory profiling and emerging technologies such as nanotechnology to support ingredient innovation in technological functionality and in delivery of sensitive and bioactive components in formulated foods. They will include the full spectrum of biological sciences necessary to develop clinically validated bio-functional food components for use in functional foods aimed at key diet-related conditions such as obesity and gut health. Capabilities will be developed in natural products chemistry for the discovery and extraction of biologically active compounds. Advanced biological and analytical techniques will be used to monitor and develop control strategies to combat existing and emerging biological and chemical hazards. Market research and intelligence

Organic Production

The Programme for Government introduced in 2007 places strong emphasis on organic food production. The key manifestation of the policy is the targeted increase, by 2012, in utilisable land area with organic status to 5% from the current level of 1%. To achieve this target, approximately 4,000 new organic producers are required to enter the sector. The challenge for Teagasc is to transfer technology and provide education and training to support farmers in the conversion process and beyond. The key areas for expansion are the beef and tillage sectors. An integrated programme built on research, advice and education will focus on providing and transferring the knowledge required to underpin competitiveness in this developing sector. We will work closely with other agencies to ensure a partnership approach in giving leadership to the expanding organic sector.

TABLE 6.4. : An extract from the Teagasc 2015 Road Map for the forestry sector.

Shape and Size of Sector	Key Targets
<p>There will be 19,000 landowners with forests with an average parcel (forest) size of 8 hectares.</p> <p>There will be approx. 800,000 hectares of forest - 11.61% land area.</p> <p>The quality of newly afforested land will be higher than in the past.</p>	<p>The minimum productivity of sites will be equivalent to Yield Class 14 Sitka spruce.</p> <p>30% of new planting will be broadleaves.</p> <p>Thinning will be carried out on at least 50% of farmer sites.</p> <p>All sites should pass Forest Service four-year inspection except in unavoidable cases.</p>

capacity to track emerging opportunities and to monitor consumer acceptance will be included.

Agri-environmental Products and Services

The overarching goals for this pillar are to: equip farmers with the knowledge to deliver high levels of agri-environmental quality; provide evidence-based knowledge to support policymakers in designing, implementing and evaluating programmes; and develop quantifiable agri-environmental measures targeted at spatial variation and different farming systems.

In conjunction with its partners, Teagasc will develop a national capability in validating the environmental effectiveness of current agri-environmental policies and practices. An important element will be to demonstrate value-for-money to taxpayers and the impact on farm profits. These goals will necessitate development of a geographical information system (GIS) with the requisite spatial resolution and information layers to identify land use, environmental conditions and impacts on the rural environment. We will identify best management practices that effectively produce desired levels and qualities of agri-environmental products and develop and implement methodologies to measure the resulting environmental benefits and objectively demonstrate the role of farmers as custodians of the countryside.

Teagasc will work to stimulate environmental innovation on farms, for instance by implementing optimal trade-offs between regulatory requirements and profitable farming. Multidisciplinary teams will be established with strong production and environmental skills to assist farmers in providing agri-environmental products and protecting biodiversity and natural resources. This programme will help farmers to implement the various measures as appropriate to their particular farm so as to become profitable and sustainable. The approach will include basic and applied research and an effective model for technology uptake through the BETTER farm programme. Teagasc will continue to develop its discussion group network to drive the adoption and development of agri-environmental products and services.

Energy and Bio-processing

This pillar includes the forestry sector, farmers, resource managers and those who produce feedstock for energy and bio-processing.

Forestry : the national strategic target is to expand forestry to 17% of the land area by 2030, with most new planting on farmer-owned land. The industry annually yields timber products, including processed timber, valued at €1.65bn. The sector also contributes to agri-environmental products and

services. A summary of the shape and size of the sector, with some key medium-term targets, is provided in Table 6.4.

Teagasc's forestry programme will help improve the quality and productivity of farm forests by developing a greater understanding of the interaction between site quality and growth. We will develop management and silvicultural intervention strategies to optimise the value of forests and quantify their contribution to greenhouse gas abatement; we will identify strategies for optimising both financial returns from farm forests and the area of farm forestry nationally; and contribute to the development of strategies that will encourage forest tourism and agri-environmental products.

Energy and bio-processing : biomass is a readily available and potentially carbon-neutral source for energy and bio-materials suited to a wide range of chemical, physical and biological uses. The development of this sector will give farmers more land use options and provide the country with an opportunity to address its energy security. Advances in conversion technology, plant genetics and biotechnology will

generate new techniques for converting biomass into valuable end-products such as fuels, 'green chemicals' and new products with high added-value. Consequently, the high level medium-term goals for this pillar are to:

- Provide evidence-based knowledge to support the planting of 70,000 ha of perennial biomass crops (Miscanthus, willow), initially for the electricity and heat markets, but ultimately for second-generation biofuel production;
- Develop the capacity of the existing biodiesel and pure plant oil industries to process up to 50,000 ha of oil seed rape and all available beef tallow; and
- Assist the sector to explore and identify higher value non-food products for bio-processing from biomass crops.

Achieving these targets will mean improving the energy ratios, greenhouse balance and sustainability of energy crops; assessing second and third-generation biofuel technologies



Product innovation is a key goal of Teagasc food research.

and the relevance of the bio-refinery concept for Ireland (whereby raw materials consisting mainly of renewable polysaccharides and lignin are fractionated and converted into a range of valuable end products); developing a portfolio of high-value industrial products that can be produced from plants; and investigating the potential of producing hydrogen from biomass.

The science needs identified include improving our understanding of biomass combustion (and how it differs from fossil fuels), and other thermal and chemical biomass break-down processes such as digestion and fermentation. We will develop our capability to exploit plant extracts such as chlorophyll, cellulose and fluffy celluloses from grass, root crops and short rotation forestry and other biomass crops. We also need to quantify the production and economic potential of products from our indigenous raw materials.

This pillar offers new opportunities, but as yet its full potential is not clear. Therefore, significant public and private investment is needed to identify opportunities for profitable investment by entrepreneurs, processors and farmers. Multi-element supply chains need to be established for this sector to work efficiently. In some cases, there will be only one consumer (e.g., electricity stations or biofuel plants), whereas the heat industry will have multiple consumers. The knowledge transfer process, consequently, requires partnerships involving farmers, Teagasc, processors and consumers. Certain applications, such as second-generation biofuel production, will require strong links between the national and international research community and specific industrial partners.

A National Bioenergy and Industrial Biotechnology Centre has been proposed by a research consortium involving Teagasc, the NUI colleges at Galway, Cork, Maynooth and Dublin, Trinity College Dublin and IT Carlow. The aim is to exploit biotechnology to generate chemicals, energy and materials from biomass and help develop the bio-refinery concept. This is now being considered for funding by Enterprise Ireland.

Resources

Food production and processing : Some 70% of resources are currently devoted to this activity. In the context of Teagasc staff and overall resources staying the same in real terms, we will have to become significantly more efficient in this area in order to allow the new and developing areas to develop. In addition, an effective technology transfer process to the food sector, including the SME sector, has to be implemented. Through better integration of staff in the planned Research and Innovation Centres, more effective use of ICT in service delivery, generation of efficiencies in administration and maximisation of income, resources will be released to allow for the necessary development within this area and also in the other growth areas identified.

Value-added food processing : currently, support for this pillar is provided through aspects of our biotechnology research programme and the substantially increased level of activity in the functional foods and nutraceutical research programmes. Our commitment to the expansion of support is indicated by the €15m investment in new laboratories and bio-test facilities, the implementation of the Research Vision Programme and engagement in a range of collaborative initiatives in the marine, dairy, beef and foods for health areas. In order to create the critical mass required, and to acquire the additional funding to extend our involvement in this area, Teagasc will compete as a partner in collaborative research programmes and technology transfer initiatives at national and international level. Overall, organisational resources in this area are less than 5% of the total, but will increase over time.

Agri-environmental products and services : components of the agri-environmental research, analytical, advisory, training and planning services are involved in the support of this pillar, amounting to over 20% of total resources. The Research Vision Programme has supported the provision of essential equipment and staff, but further investment will be necessary in laboratories and staff. Analytical and environmental planning services (REPS and Derogation Nutrient Planning) utilise very substantial resources, but are an essential high quality service for the farming community. These services are self-financing. Efficiencies in the delivery of services will be sought in order to divert new resources

towards an enhanced research and development programme on the environment.

Energy and bio-processing : current support for this pillar is through a limited research programme, knowledge transfer through specialised advisors, activities in increasing awareness of opportunities and training programmes for forestry and bioenergy production and utilisation. About 3% of overall resources are devoted to this area and this will grow significantly over time, largely through our involvement in the proposed National Bioenergy and Industrial Biotechnology Centre, involvement in campaigns to increase awareness and knowledge transfer services to land owners and to industry.

Rural Environment and Rural Economy Programmes

Competitiveness and environmental sustainability cut across all four pillars of the bioeconomy. Hence, the current rural economy and environment research programmes are cross-cutting and will contribute both directly and indirectly to achieving the goals outlined above. Specific programme goals have also been set for these programmes. In particular, they provide evidence-based research to support agricultural, environmental and economic policy development and legislation.

The environmental research programme is not just essential for maintaining biodiversity and prudent stewardship of natural resources, it also makes sound economic, commercial and financial sense for farmers. Sustainability is vital for future success and, significantly, the environment is now a 'product', with an economic value, and is also of immense importance to society. The result of Teagasc's environment research and dissemination programme will be a double dividend, or 'win-win' situation for farmers, the rural economy, the bioeconomy and Ireland as a whole.

Teagasc will generate and disseminate knowledge that supports a whole-farm approach to sustainable farming and provides strong support for policymakers. It will also establish adaptable technology platforms for agri-environmental practice and policy to provide evidence-based knowledge and decision support systems for farm-level management

strategies and future national strategies in areas such as land use changes and best management practices. To deliver on these goals, we will develop multi-disciplinary teams, with a strong production, economic and environmental capacity to assist the diverse needs of our clients, protect natural resources and provide agri-environmental products. Short-to-medium-term goals include:

- Improving nitrogen and phosphorus efficiency to reduce input costs and protect water and air quality;
- Developing decision support systems to support farmers with nutrient management for fertilisers and manures;
- Identifying a range of mitigation and abatement strategies to address greenhouse gas emissions and the challenge of climate change;
- Developing soils information systems to underpin sustainable land use and management decisions;
- Improving our understanding of soil chemical and microbiological processes to improve the targeting of measures that will reduce farm costs and protect soil, water, air and biodiversity; and
- Undertaking applied and fundamental research to support cost effective delivery by farmers and land owners of quantifiable agri-environmental products and services.

A major aim is to integrate the various components of the organisation's existing agri-environmental research programme to ensure we produce whole-farm solutions and that we do not mitigate one environmental problem at the expense of another. To that end, we are developing and disseminating farm management practices that simultaneously address nutrient efficiency, water quality, gaseous emissions, soil quality and agro-ecology. These all-encompassing holistic solutions will be customised to the varying needs of our different farmer groups.

The goal for the **Rural Economy Programme** is to provide

evidence-based knowledge to support decision making within the bioeconomy centred on achieving maximum value for money and competitive rates of return on investment decisions; to promote efficiency and competitiveness within the sector; to support strategic planning and policy intervention that achieve objectives with minimum economic cost and maximum economic benefit; and finally, to maximise the contribution of agri-food and other sectors to the viability and sustainability of rural areas.

Some of the high level research objectives are to:

- Improve our understanding of the economics of alternative farm options and enterprises to ensure maximum value-for-money and appropriate rates of return on investment decisions;
- Collect data to support market intelligence and sub-sectoral analysis within the agri-food sector;
- Support government and other agencies to plan and develop policies for the sector;
- Understand how environmental obligations affect potential competitiveness and productivity, and help design better environmental policy;
- Estimate the value of ecological resources (e.g., forests, rivers, outdoor recreation on agricultural land) to assess the costs and benefits of environmental policies;
- Quantify the impact alternative processing sector decisions and strategies have on farm profitability;
- Evaluate the impact of the agri-food sector on the economic viability of rural areas; and,
- Monitor the impact of non-agri-food policies on the welfare of our stakeholders.

The resources needed to implement this comprehensive research programme are skilled economic and analytical

experts who also possess an understanding of the agri-food sector; have access to high quality up-to-date data and market intelligence and sophisticated ICT and modeling tools to convert this data into usable knowledge and information.

Conclusion

Ireland has the potential to build a vibrant world-class bioeconomy for the benefit of farmers, the agri-food industry, the rural economy and the country as a whole. Knowledge generation and innovation will be crucial to ensuring that the agri-food sector and rural economy is profitable, competitive, successful and environmentally sustainable, while knowledge transfer will be the key step in turning research into added value. Teagasc will establish integrated programmes, develop technology platforms and create knowledge transfer services customised to meet the different needs of its clients. Through these connections, and with support from our partners, we will deliver the evidence-based knowledge and innovation support required to facilitate the agri-food and rural economy sector take advantage of the emerging opportunities and address the significant challenges in the short-to-medium term.

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Appendix 1 : Foresight teams

Steering Committee

Chairman: Prof Seamus Smyth, President Emeritus, NUI Maynooth

Ms Helena Acheson, Division Manager, Science, Technology and Innovation Policy and Awareness, Forfás

Prof Gerry Boyle, Director, Teagasc (from October 2007)

Mr James Brett, Member, Teagasc Authority

Prof Liam Donnelly, Director of Food Research, Teagasc

Dr Mary Kelly, Director General, Environmental Protection Agency

Mr Patrick Kelly, Teagasc Authority

Mr Tom Kirley, Director of Administration, Teagasc

Mr Mike Magan, Chairman, Lakeland Dairies and farmer

Mr John Malone, consultant, former Secretary General, Department of Agriculture, Fisheries and Food

Mr Larry Murrin, CEO, Dawn Farm Foods Ltd.

Mr Aidan O'Driscoll, Assistant Secretary, Department of Agriculture, Fisheries and Food

Dr Tom O'Dwyer, Chairman, Teagasc Authority

Prof Dr Fons Werrij, Euragri Secretary General, Wageningen WUR

Dr Lance O'Brien, Teagasc, secretary to steering committee.

Foresight Panel

Dr Tom Beresford, Teagasc, Moorepark

Mr Seamus Boland, CEO, Irish Rural Link

Prof Maurice Boland, School of Agriculture, Food Science and Veterinary Medicine, UCD

Mr Pdraig Brennan, Senior Business Analyst, Bord Bia

Mr Paddy Browne, Assistant Director of Training and Development, Teagasc

Prof Jimmy Burke, Head of Centre, Teagasc, Oak Park

Mr Ross Campbell, Managing Director, CyberColloids Ltd.

Dr Owen Carton, Programme Manager, Teagasc, Johnstown Castle

Mr Dominic Cronin, Chairman, ICMSA Dairy Committee

Dr John Curtis, Environmental Protection Agency

Dr Michael Diskin, Programme Manager, Teagasc Mellows Research Centre, Athenry

Mr John Fennessy, Research Programme Manager, COFORD

Mr Gerry Finn, Director, BMW Regional Assembly

Prof Gerard Fitzgerald, Faculty of Food Science and Technology, UCC

Dr Aidan Fitzsimons, Commercial Director, Dairygold Co-operative Society

Mr Jim Flanagan, consultant (Chairman)

Ms Ruth Hegarty, Secretary-General, Euro-Toques Ireland

Dr Thia Hennessy, Teagasc, Rural Economy Research Centre, Athenry

Mr Dermot Jewell, CEO, Consumers' Association of Ireland Ltd

Ms Ann Kehoe, National Director, GEGA

Mr Paul Kelly, Director, Food and Drinks Industry Ireland, IBEC

Dr Tom Kelly, Programme Manager, Advisory Services, Teagasc
Mr Con Lucey, Chief Economist, Irish Farmers' Association
Mr Colm Markey, former National President, Macra na Feirme
Prof Alan Matthews, Department of Economics, TCD
Dr John Mulvihill, Enterprise Ireland
Ms Helen Murphy, Deputy Head, Economics and Planning Division,
Department of Agriculture, Fisheries and Food
Dr John O'Brien, CEO, Food Safety Authority of Ireland
Dr Mairead O'Driscoll, Head of Policy, Evaluation and External Relations Unit, Health Research Board
Dr James O'Sullivan, PA Consulting Group
Mr Michael Sheridan, Deputy Chief Veterinary Officer, Department of Agriculture, Fisheries and Food
Dr Maurice Treacy, Director, Biosciences and Bioengineering Directorate, Science Foundation Ireland
Mr Declan Troy, Head, Teagasc, Ashtown Food Research Centre.

Working Group

Dr Lance O'Brien, Teagasc, Head Office (Project Manager)
Dr Declan Bolton, Teagasc, Ashtown Food Research Centre
Dr Owen Carton, Teagasc, Johnstown Castle Research Centre
Mr Pat Murphy, Teagasc, Advisory Services
Dr Cathal O'Donoghue, Teagasc, Rural Economy Research Centre
Mr Tony Pettit, Teagasc, Education and Training
Dr Catherine Stanton, Teagasc, Moorepark Food Research Centre.

Appendix 2: Submissions received and stakeholder meetings

Following publication of a notice in the media and on the Teagasc website on 8 November, 2007, inviting submissions, Teagasc received submissions from the following:

- 1: BioRefinery Ireland
- 2: Bord Bia
- 3: Bord na Mona
- 4: Federation of Irish Beekeepers' Associations
- 5: Gadera Ltd.
- 6: Irish Egg Association
- 7: Irish Grain and Feed Association
- 8: Irish Organic Farmers' and Growers' Association
- 9: Irish Rural Link
- 10: Irish Timber Growers' Association
- 11: Marine Institute
- 12: Dr Roy H W Johnston
- 13: Prof Simon Moore

Stakeholder Meetings

Consultation meetings with key stakeholders were held in January-February 2008:

Food and Drinks Industry Ireland	22 January 2008
Irish Creamery Milk Suppliers' Association	24 January 2008
Macra na Feirme	24 January 2008
Irish Co-operative Organisation Society	31 January 2008
Irish Farmers' Association	1 February 2008
Department of Agriculture, Fisheries and Food	4 February 2008
Irish Cattle and Sheep Farmers' Association	8 February 2008

Briefing for semi-State agencies and the third-level sector: 23 January 2008.