AGRICULTURE AND FOOD DEVELOPMENT AUTHORITY
Teagasc Technology Foresight 2035

Food, Health and the Role of National Reference Laboratories
Conference
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Presentation Outline

• The Global Context: Global Megatrends and Drivers of Change

• Needed Transformation in Global Agri-Food

• The Teagasc Response: Technology Foresight Project
  • Project Overview
  • What is Foresight?
  • Project Structure
  • Project Process

• Visions for Five Key Transformative Technologies to Transform Irish Agri-Food

• Other Conclusions

The Irish Agriculture and Food Development Authority
The Global Context: Global Megatrends and Drivers of Change

• Food and Nutrition Security
  • Increasing population and income

• Climate Change

• Pressure on Natural Resources

• More Sustainable Lifestyles and Consumption Patterns

• Growth of Bioeconomy and Circular Economy

• Emergence of Disruptive New Technologies

• Food Harvest 2025: Opportunities for Growth
Disruptive Technologies

• Spate of disruptive innovation from rapidly accelerating scientific discoveries and new technologies creating major economic shifts and introducing new opportunities and risks
  • Big Data, 3D Printing, Artificial Intelligence, Robotics, Synthetic Biology, Nanotechnology, Biotechnology
• Cycles of technology-induced change have accelerated in the past decade-evidence of exponential rather than linear growth for some technological progress as new technologies converge
• We cannot even begin to conceive of the wider social and economic impacts of these technologies in the long term
• Who foresaw second-order effects of the Internet (Facebook and Twitter) or third-order effects like the use of these innovations for social movements/upheavals (Arab Awakening)?
• Eventually they could conceivably impact all sectors of the economy
• Government, business and society will need to collaborate to introduce policies and institutions to make best use of these new technologies
• We need to prepare in the agri-food sector
Teagasc Response

• Teagasc is committed to the development and application of cutting-edge sustainable processes and technologies

• These are key to achieving improved international competitiveness, responding to the changing needs of the market and the consumer, enhancing the sector’s environmental sustainability and developing value-added foods on the home and international markets

• Through Foresight, we will identify the breakthrough technologies which over the long term will enable the Irish agri-food sector and bioeconomy realise its full potential for sustainable growth
The identification of the key technologies that have the potential over the next 20 years or so to underpin competitiveness, sustainability and growth in the Irish agri-food and bioeconomy sector.
What is Foresight?

“A change management tool that helps leaders and those responsible for change to...
• Clarify the challenges they face
• Elaborate a hopeful vision of what can be achieved
• Prioritize the actions required and
• Understand the kind of collaboration needed to succeed”
Foresight Approach

• A willingness to change
• A focus on thinking about the “far” future …
• A diversity of views from different stakeholders

• Understand Broader **Contextual** Barriers to or Factors for Success
• Clarify **Systemic** Issues
• Escalate ‘what now?’ questions of **how to act** in immediate future

This requires both a structured approach based on **PROCESS** and **CONTENT**…

Typically this means working with two different modes:
• **DIVERGENT MODE** where every effort is made to move away from usual paradigms, to focus on what is new and prepare the mind for new thinking. This is where new goals and ambitions are created.
• **CONVERGENT MODE** where the group starts to focus on priorities, making choices about what to do next, how to do it and with whom.
The Overall Foresight Process

FW0: Pre-Foresight Workshop
- Breakthrough Technology Identification Workshop

FW1: The TCWG (Technology Cluster Working Group) get up and running...
- Theory of Change Workshop + SCM

FW2: The TCWGs continue to refine and develop their thinking...

FW3: The TCWGs continue their work between meetings...
- Preliminary Scenarios Workshop

FW4: Deep-Dive WS on "New Questions, New Organisation, New Partners" + SCM
- Vision and Final Scenario Workshop + SCM

FW5: Stakeholder Workshop
- 2015 September 17

FW6: The TTF2030 Conference
- 2016 January 12

From now on the TCWGs and expert panel members have important roles to play as ambassadors for the vision, and as agents of technological change...
Needed Transformations in Global Agri-Food

To address the unprecedented challenges that lie ahead the food system needs to change more radically in the coming decades than ever before, including during the Industrial and Green Revolutions”. (UK Food and Farming Foresight, 2011, p.176)

- Producers will need to modify their methods in a way that will not further degrade the environment nor further compromise the world’s capacity to produce food in the future

- It will also be critical to tackle waste and consumption distribution

- Future food production systems must be sustainable in terms of delivering a supply of safe, healthy food with low environmental impacts in terms of emissions and biodiversity
Sustainable intensification

- **Sustainable intensification has been defined as producing more from the same area of land while reducing negative environmental impacts and increasing contributions to natural capital and the flow of environmental services**

- avoiding the unnecessary use of external inputs;

- harnessing agro-ecological processes such as nutrient cycling, biological nitrogen fixation;

- quantifying and minimizing the impacts of system management on externalities such as greenhouse gas emissions, clean water availability, carbon sequestration, biodiversity and dispersal of pests, pathogens and weeds.
Science and Technology

- Sustainable intensification is not defined in terms of any specific technologies or farming practices

- The most important goal is that if a technology results in efficient food production without adverse ecological consequences, then it is likely to contribute to the system’s sustainability

- Need a multifaceted research portfolio that helps build capacity in modern biotechnology and other platform technologies, but also strengthens capacity in traditional crop and animal sciences and technologies, as well as embracing traditional local technologies

- Teagasc Technology Foresight presents five areas of transformative technology for a sustainable, competitive and resilient Irish Agri-Food Sector in 2035
1. Plant and Animal Genomics and Related Technologies

- Low cost genotyping and sequencing has enabled this technology area to develop rapidly
- Genomic selection in dairy cattle is one successful application
- Potential to transform breeding of high performance plants and animals with different traits
Future applications for livestock?

- Beef genomic selection in 2016 – sheep possibly in 2017
- New traits
  - Animal health, meat and milk quality, feed intake
- Lower cost genotyping at higher density
  - Full (imputed) sequence $15m → $7.08
  - Better prediction of total genetic merit
- More efficient and effective computer prediction models and hardware
  - More real-time and accurate predictions
- Holistic, real-time, dynamic, stochastic & precise low-cost decision support tools
  - Superior management recommendations
- Increased overall, balanced performance (genetics + management)
Future applications for crops?

- Breeding programmes will characterise breeding lines of interest via mainstream ‘genotype-by-sequencing’
  - Allow quicker identification of ryegrass, potato, cereal lines with high agronomic potential for GxExM field analysis

- Transcriptome sequencing (RNAseq) of breeding material will allow rapid association of gene(s) with high value traits
  - Applied to germplasm grown under controlled/field conditions
  - Real opportunity to deliver novel varieties with, for example, improved disease resistance, NUE, abiotic stress…

- Genome editing will deliver the ‘proof-of-concept’ based on functional genomics studies
  - Gene activity can be modulated (up/down/off) within crop genomes via ‘molecular scissors’ to edit what is already there

- Supported by ‘ease-of-use’ computational resources to facilitate decision making
2. Exploitation of Microbiota

- The totality or community of microbes in a particular organism, place or environment
- Human microbiota, animal, plants, soil
- The human microbiota has received much recent attention
- Rapidly expanding evidence that the human microbiota influences development and health status (both physical and mental)
- Microbiota changes with age, level of general fitness and the foods we eat
- Manipulating and controlling the human microbiota has significant potential in promoting enhanced health and fitness levels
- The Human Microbiota is a very active research area within Teagasc Food Programme with particularly strong collaboration with UCC including School of Medicine
Exploitation of the Microbiota

- Animal Microbiota
  - Many studies are demonstrating that the animal microbiota are having similar effects on their hosts as the human microbiome has
  - Animal production could exploit the microbiota to promote health and production efficiency (as is now happening for humans)
  - Manipulation of the animal microbiota may also be a route to desired environmental impacts

- Plant Microbiota
  - Plant microbiota can be either external (rhizosphere) or internal (root nodules, endophytes)
  - Manipulation of the plant microbiota could lead to production efficiencies and positive environmental impacts

- Environmental Microbiota
  - Soil, air and water are major reservoirs of microorganisms
  - Application of microbiota approaches to the environment is likely to lead to major breakthroughs in terms of production efficiency and environmental health status
What future developments can be expected?

• Over the next 15-20 years we can expect:
  • Very significant applications in this area that will involve enhanced agricultural efficiency, reduced emissions, lower animal/plant disease levels, enhanced food quality, foods to promote health etc
  • Just as the “Internet of Things” is now becoming a reality the “Microbiota of Things” will have become established as a key driver in agriculture and food
3. Digital Technology in Livestock Farming Today

Many more: robotic milking, animal monitoring, milk supply forecasting, nutrient management, weather forecasting, environmental measurement.....

Genotyping the herd

Biosensors in veterinary diagnostics

PastureBase Ireland

Warning and virtual fence lines

Exclusion Zone

Real Cow

GPS

Grazing Allocation

IDB SNF CHIF INTERNATIONAL DAIRY & REEF SNF CHIF
Digital Technology in Arable Farming Today

- Collect data from a distance to evaluate soil and crop health (moisture, nutrients, compaction, crop diseases). Data sensors can be mounted on moving machines.

- Achieve accuracy when driving in the field, providing navigation and positioning capability (e.g., GPS).

- Produce maps including soil type, nutrient levels, etc. in layers.

- Assign that information to the particular field location.

- Maintain tire inflation to a preset level, automatically inflating tires that are below target pressure or allow an operator to change tire pressure easily according to weight, speed and soil conditions.

- Sensor and remote sensing, high precision positioning systems, geomapping.

- Adapt intelligent seeds/chemical inputs prescription based on soil properties and analysis.

- Use genetically transformed seeds to reach even higher productivity.

- Take over specific driving tasks like auto-steering, overhead turning, following field edges and overlapping of rows.

- Automated tire inflation systems.

- Variable rate technology.

- Integrated electronic communications.

- Automated steering systems.

- Variable rate technology.

- Enable communication between components in a system (e.g., telematics - communication between tractor and farm office, tractor and dealer or spray can and sprayer).

- Adapt parameters on a machine to apply, for instance, seed or fertilizer according to exact variations in plant growth or soil nutrients and type.

The Irish Agriculture and Food Development Authority
Future Impacts of Digital Technology

- Enable farmers to monitor each individual plant or animal on the farm and manage production and harvesting using that knowledge
- Will deliver more flexible and ever-more precise agriculture
- Add traceability to the farm’s menu of information services and underpin high food safety standards
- Use less inputs on-farm, but produce more output using intelligent machines
- An increasingly valuable output will be the transformed raw data and meta-data arising from information-rich agricultural practices that will add more value to the farm’s products (data sold with the product)
- These opportunities could be held back through inappropriate proprietary system/technology lock-out
- The massive quantity of raw data generated across the entire agri-food supply chain presents a significant systems integration task
4. Advanced Food Processing Technologies

- Advanced manufacture-next generation food processing technologies
- Food structure: soft matter/food physics (foods optimised for maximum nutrient density)
- Process Analytical Technology (PAT): in-line sensors in food processing, rapid techniques for quality and safety
- Bio-transformation
- New value chains (novel separation technologies for side streams)
- Technologies for water/energy reduction
- Preserving quality (packaging, logistics, safety, reduced wastage)
- Advanced analyticals for chemical composition and safety of food
- Big data (engaging with the consumer, food scanners, food traceability)
5. New Value Chains

- Moving up the value chain will require greater integration across the agri-food supply chain. A more integrated value chain requires
  - Proper consumer-based price and market information
  - Behavioural Science to understand the motivations and drivers of the different components
  - Developments in cognitive sciences and behavioural economics can provide behavioural tools to help facilitate improved outcomes
  - Organisational developments so that the value chain can work seamlessly as a single unit responding to consumer need rather than a series of competing autonomous entities
  - Information technologies to facilitate information flows
Beyond FH 2025: Further Opportunities?

• **New opportunities in Non-food Markets**
  • OECD estimates that the bioeconomy could contribute over $1 trillion of Gross Value Added in OECD countries by 2030, of which 36% would come from primary agricultural production
    • Bioeconomy and Circular Economy

• **The Technology Revolution**
  • Ireland can become a global leader in areas of agricultural technology innovation and benefit from growing global agri-tech markets
  • Ireland can lead in building sustainable agricultural production systems and more sustainable consumption patterns associated with reduced waste, and market this expertise globally
  • Ireland’s research strengths in food for health enables it to exploit new opportunities for novel high-value nutrition and wellness products and functional ingredients

• **Research and Development Services**
  • Opportunities for researchers to link with counterparts around the world and make Ireland a centre for internationally mobile R&D undertaken by public and private sectors

The Irish Agriculture and Food Development Authority
Keep in Touch with Foresight

Invitation to make a Submission to Teagasc Foresight Project

- http://www.teagasc.ie/about/our-organisation/foresight