East of England Science and Innovation Audit

Appendix 2 – Agri-tech

Contents

Agri-tech Theme Paper

Scope – and core hypothesis relating to commercialisation and collaboration

1.1 Over the last decade, East of England has led the way nationally in recognising the scope, potential and wider significance of agri-tech [1]. In part this reflects its strong heritage in crop-based agriculture and horticulture. But equally important is the depth and calibre of scientific research in the field – *and* the recognition that new disciplines (perhaps most especially informatics and automation) have a crucial future role to play. Key elements of the innovation ecosystem within the region are summarised in Figure 1-1.

Figure 1-1: Summarising the East of England's Innovation Ecosystem in Agri-tech

(Source: SQW)

1.2 Within this context, the Agri-tech theme focuses on four main elements: **tools and techniques to improve agrifood productivity; enabling technologies in engineering, robotics, ICT and data; primary production, food manufacture and logistics;** and **circular bioeconomy.** The region's scientific research strengths and innovation capabilities in these domains are summarised in the remainder of this paper.

1.3 The hypothesis that has shaped the Audit process is as follows:

The region has world-renowned research strengths in Agri-tech, and increasing expertise and experience in the process of commercialisation. Further strengthening of the mechanisms for commercialisation will bring major economic benefits to the region and to the national economy.

1.4 The evidence that has been gathered to test this hypothesis is summarised below.

[1] A full definition of Agri-tech is included in Annex B

National and international trends, and size of global markets

Key trends and drivers

1.5 The key trends and drivers affecting Agri-tech at national and international levels include:

- Pressure for sustainable intensification, producing more food on less land with fewer inputs to meet the food security needs of an expanding global population. For example, it is predicted that more than 30% of protein consumed in 2050 will be from non-animal sources, demonstrating the need for new sustainable sources of protein to feed the growing world population[2].
- Increasing use of technology such as IT, satellites, remote sensing and proximal data gathering to optimise returns (both arable and pastoral) on inputs and potentially reduce environmental impacts by, for example, reducing the amount of pesticides used and to counter water scarcity[3].
- Reducing the burden of diet related disease in human, livestock and poultry through improved nutrition
- Resilience to climate change[4], and protection for the environment and biodiversity
- Zero waste processing – ingredients are considered increasingly valuable if their 'co-products' can themselves be used to develop additional value streams and thus eliminate wastage[5]
- Changes in values and ethical stances of consumers resulting in moves towards a health and nutrition focus[6]. Examples include the acceptability of modern technology (e.g. genetic modification), the value placed on animal welfare, the importance of sustainability, and reformulation to reduce salt, sugar and fat in food products
- A need to reduce the requirement for low-skilled labour in primary agriculture in many advanced western countries is now a global trend with China now the World's largest investor in robotics. In the UK this issue is rapidly increasing in importance in anticipation of the consequences of Brexit in a sector which has for over 20 years been very dependent on EU migration to meet its labour needs

1.6 Innovation in Agri-tech is responding to these trends at six levels: agricultural practice (agronomy); development and application of agricultural inputs; varietal improvement (breeding); automation (robotics, precision agriculture and contained production); precision agriculture approaches including use of big data; and reduction in inputs (Smart Ag).

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[2] Technology Transforming Irish Agri-Food and Bioeconomy, Teagasc, 2016
[3] Precision Agriculture: An Opportunity for EU Farmers – Potential Support with the CAP 2014-2020, EU, 2014
[4] The Future of Food and Farming, The Government Office for Science, 2011
[5] Sustainable manufacturing for the future: Investigating the current and future landscape across the food and drink industry in Great Britain, Cranfield University and Coca Cola Enterprises, 2015
[6] The Future of Food and Farming, The Government Office for Science, 2011
Sustainable manufacturing for the future: Investigating the current and future landscape across the food and drink industry in Great Britain, Cranfield University and Coca Cola Enterprises, 2015

Global Agri-tech markets

1.7 UKTI in its market assessment of the global Agri-tech sector estimated the global market for Agri-tech in 2011/12 at £142billion, supplied by 212,000 businesses and employing 4.7millon people[7]. This assessment used a definition of Agri-tech which excluded livestock feeds and most fertilisers. Key sectoral statistics in this study are provided in Table 1-1.

Table 1-1: Global value of Agri-tech by sector, 2011/12, £m

Agri-tech sub sector	Value £m	Companies	Employees
Agri-engineering	55,090	82,712	1,830,720
Animal health	28,752	43,178	955,343
Animal breeding	12,603	18,623	416,397
Sensor technologies	12,284	18,320	408,147
Services (e.g. consultancy)	10,548	15,572	342,215
Plant health	10,202	14,570	337,931
Plant breeding	10,027	15,424	331,566
Water management	2,216	3,255	74,063
Plant nutrition*	184	238	6,241
Total global market	141,907	211,892	4,702,623

Source: UKTI. Note: plant nutrition excludes fertilisers

1.8 Estimates of market size in related industries include:

- Global agriculture was valued at $3.9trillion in 2013 of which crops contributed $2.64trillion and livestock $1.26trillion. Whilst the growth of non-food crops continues, on a global basis their farmgate value, $0.12trillion, is still much smaller than the market for food[8].
- The total food market is worth approximately $7trillion, which is nearly five times the value of the global automotive market (circa $1.5trillion in 2015[9]). Over the longer term, the Foresight Report[10] estimated that global food demand would rise by 50% by 2030 and 60-100% or more by 2050.
- The USDA (2011)[11] looked at global R&D expenditures on agriculture and food and found that in 2010 global private sector investment in agricultural input R&D reached $11.03bn (a doubling from $5.58bn in 1994).

[7] UKTI (2013), AgriTechnology Sector: Market Trends and Opportunities Report
[8] FAO (2015), Macro Statistics
[9] Statista (2015), Revenue of the leading automotive manufacturers worldwide in 2014
[10] Beddington, Professor Sir John, Government Office for Science (2011), Future of Food and Farming: final project report
[11] USDA (2011), Research Investments and Market Structure in the Food Processing, Agricultural Input and Biofuel Industries Worldwide

Agri-tech in Europe

1.9 There is widespread agreement that significant increases in agricultural productivity and sustainability require increased investment in research[12], the technology this leads to and its translation and adoption by business[13]. However, a 2008 report from the European Commission Standing Committee on Agricultural Research (SCAR)[14] summarised the problems inherent in the delivery of agricultural knowledge systems (AKS) as:

"Over the years, as they have been to an increasing extent privatised, there has been a progressive dis-investment by public authorities in AKS. Many countries … have dismantled to a considerable extent the basis for dis-interested science and public good training and advisory services, as well as the mechanisms [for] applied and adaptive research…..AKST infrastructures at European level are not organised … to provide adequate capacity (infrastructures and expertise) to integrate agricultural, health, food, climate change and environmental knowledge, science and technologies'. To address this weakness the EU has given a higher status to Agri-tech in its Horizon 2020 research programme and developed a European Innovation Partnership for Agriculture (EIP Agri)"[15].

1.10 A key finding from this SIA (which will be explored further in later sections of this paper) is that, despite these concerns about disinvestment across Europe, the East of England has an exceptional scale, quality and diversity of scientific research in Agri-tech and related areas, and its translation into leading edge applications.

UK Agri-tech

1.11 Table 1-2 provides summary information on the scale of the UK agriculture and food sector.

Table 1-2: Turnover, GVA and Employment in the UK Agriculture and Food Sector

	2006	2010	2015	Trend 2006-15
Turnover (current prices)				
Agriculture	£14.5bn	£20.6bn	£23.8bn	+64%
Food – retail & catering total sales	£155bn	£171bn	£201bn	+30%
GVA				
Agriculture	£4.9bn	£6.9bn	£8.5bn	+74%
Food – total of food processing, wholesaling, retailing & catering	£72.7bn	£82.2bn	£98.4bn*	+35%
Employment				
Food Chain	3,662,000	3,536,000	3,851,000	+5%

Source: DEFRA (time series), Agriculture in the UK: 2015, data tables Chapter 13, Table 13.1 Agri-food sector contribution to the national economy; United Kingdom

[12] Beddington, Professor Sir John (2011), Foresight: The Future of Food and Farming (2011) Executive Summary, the Government Office for Science, London.
[13] Royal Society (2009), Reaping the benefits: Science and the sustainable intensification of global agriculture
[14] Brunori G, Jiggins J (rapporteur), Gallardo R, Schmidt O (2008), EU Commission Standing Committee on Agricultural Research (SCAR): 2nd Foresight Exercise - New Challenges for Agricultural Research: climate change, food security, rural development, agricultural knowledge systems
[15] European Innovation Partnership 'Agricultural Productivity and Sustainability' - EIP Agri, http://ec.europa.eu/eip/agriculture/

1.12 UK agricultural policy has promoted the need for sustainable intensification with reports including Food 2030 (2010) and the Foresight Report (2011)[16] promoting the need to increase production whilst addressing the sector's environmental footprint. In addition, the NFU report Feeding the Future (2012, currently being updated[17]) identified priorities for agricultural research over the next two decades including, for example, use of modern technologies to improve the precision and efficiency of key agricultural management practices, and applying modern genetic and breeding approaches to improve the quality, sustainability, resilience and yield-led profitability of crops and farm animals.

1.13 Given the growth in demand for agricultural technology and the UK's strong research base, the UK government developed a UK Strategy for Agricultural Technology[18] launched in 2013. This recognised agri-tech as a key growth sector alongside a further 10 sectors in the government's Industrial Strategy. These 11 priority growth sectors are enabled by *Eight Great Technologies*, which includes Agri Science as well as others which are directly relevant to Agri-tech, including Big Data, Robotics and Energy Storage[19].

1.14 Investment in Agri-tech inputs by UK farmers grew by 73% from 2006-14, as higher crop and livestock prices both pushed up the cost of inputs whilst at the same time encouraging farmers to purchase more to help them increase production[20].

Local science and innovation assets

1.15 Three main perspectives are provided on the region's science and innovation assets: the institutions, research funding and outputs, and areas of distinctive expertise.

The region's institutions

1.16 These include eight Universities, five BBSRC research centres, three independent research centres, and three Agricultural Colleges. Tables 1-3 and 1-4 provide summary information for a selection of these institutions. Many of these institutions work collaboratively together. For example, the Cambridge Centre for Crop Science (3CS) is a new initiative between the University of Cambridge and The National Institute for Agricultural Botany (NIAB) that will provide leadership in crop sciences, fostering a flexible and dynamic research environment, whilst training the next generation of expertise needed to deliver sustainable yields for the future. 3CS will work with partners across the region to become a hub for addressing the challenges in Agri-Tech research.

[16] Foresight report (2011), Global Food and Farming Futures
[17] http://www.nfuonline.com/cross-sector/science-and-technology/research-and-innovation-news/feeding-the-future-four-years-on-a-review-of-innovation-needs-for-british-farming/
[18] Her Majesty's Government (2013), UK Strategy for Agricultural Technologies
[19] BIS (2015), Smart Specialisation in England: submission to the European Commission
[20] DEFRA (2015), Agriculture in the UK 2014 (and earlier annual reports)

Table 1-3: Examples of research and training centres active in Agri-tech in the region

Institution	Brief description
Centre for Environment, Fisheries and Aquaculture Science (CEFAS)	A national facility supported directly by government as a national laboratory for fish, sea and environmental related research
National Soil Research Institute	Particular strengths in three significant Agri-tech topics: water; soils; engineering, as well as management and leadership research and education.
Hinton Park for Agri-tech	Still being planned (planning application due in summer 2017), this site will be a dedicated Agri-tech business park to the south of Cambridge with a projected 1million square feet of space as well as access to thousands of hectares of crop and technology trial sites. It aims to be the largest dedicated Agri-tech park in the UK.
Institute for Manufacturing and the Sainsbury Laboratory	These are both part of the University of Cambridge and have direct links into science, technology and management systems which support the food chain and Agri-tech sector.
National Centre for Food Manufacturing (NCFM) and Lincolnshire Institute for Agri-Food Technology (LIAT)	This centre, in the GCGP area in South Lincolnshire is a national facility which works very closely with over 300 companies and which is also due to become the anchor tenant on the Holbeach Food Enterprise Zone (FEZ). It has a very applied focus to its work and is known to be keen to collaborate with other development sites. It is managed by a team of academics with very strong commercial backgrounds
NIAB	A national centre for plant research, crop evaluation and agronomy, with its own network of farm research sites across the UK as well as its Cambridge HQ and out-centre at Hasse Fen (focused on food waste reduction). NIAB works closely with industry
John Innes Centre, Quadram Institute (formerly Institute for Food Research), Earlham Institute (formerly the Genome Analysis Centre (TGAC)), Sainsbury Laboratory, located on Norwich Research Park	Norwich Research Park generates research income of £100m per annum, employs over 3,000 scientists and 12,000 staff in total. It has seen major investment in site infrastructure and facilities (£26m in the last 3 years).It is located on a 230 hectare site and hosts: • three out of the 8 national BBSRC sites – ➢ the John Innes Centre, an independent, international centre of excellence in plant science and microbiology, which receives BBSRC funding for four research areas: genes in the environment; plant health (in partnership with The Sainsbury Laboratory); molecules from nature; and designing future wheat (a cross-institute strategic programme) ➢ Quadram Institute, the only publicly funded UK research institute that focuses on the underlying science of food and health to address the global challenges of food security, diet & health, healthy ageing and food waste ➢ Earlham Institute, which focuses on exploring living systems by applying computational science and biotechnology to answer ambitious biological questions and generate enabling resources • the Sainsbury Laboratory, which undertakes research into plant disease and resistance, and microbial symbiosis in plants. • the UEA and Norfolk and Norwich University Hospital • a range of about 75 mainly small start ups and spinout companies. BBSRC is also due to invest £80m in the Quadram Institute by 2018 which will see IFR, part of the UEA Medical School and gastroenterology from the hospital merged into a new national facility focused on food and dietary health.
Rothamsted Research	A national facility and the oldest agricultural research centre in the World. Rothamsted is supported by BBSRC strategic funding and focusses on three portfolio areas: Superior Crops, Securing Productivity, and Future Agri-food Systems. It is also the site of the first Centre for

Institution	Brief description
	Agricultural Innovation set up by the UK Strategy for Agricultural Technology, the AgriMetrics Centre
Wakelyns Agroforestry	Wakelyns Agroforestry is an organic research farm certified by the Soil Association, and is part of the Organic Research Centre.
Writtle University College	A long established national provider of Further and Higher Education in agriculture and related subjects with 750 Higher Education students. It is active in many areas of relevant research with a few areas, e.g. post harvest technology, having a global reputation and connectivity.

Table 1-4: Examples of HEIs' involvement in Agri-tech in the region

Institution	distinctive strengths
University of Cambridge	The main strengths of Cambridge University in relation to agri-tech spans a number of different departments and institutes including: Plant Sciences; Biochemistry; the Sainsbury Laboratory; Chemical Engineering and Biotechnology; Engineering; Chemistry; Genetics; Geography; and, Materials Science and Metallurgy. They also span five strategic Agri-tech sector themes: • Food Security – Plant pathology, crop protection towards both pathogens and environmental factors, disease resistance and yield improvement • Climate Science and Ecosystem Conservation – Plant molecular, physiological and environmental responses • Precision Agriculture/Automation – Development of sensors that assess maturity in plants and plant/animal health, robotic applications for farming (e.g. crop harvesting) • Sustainable Farming – Working towards better use of resources (land, water, energy), more efficient supply chains and minimising the environmental impact of the road freight sector • Bioenergy – Understanding cell wall biosynthesis, use of plants and algae for biofuel and solar fuel production
Cranfield University	Strengths in precision-agriculture, post-harvest, and soils science Manage the national reference centre for soils and world soils archive - using unique soil datasets and sensor-based diagnostics to provide new solutions for improving precision agriculture and soil health Innovative plant breeding and food storage solutions to better utilise resources and reduce waste Identification of risks and opportunities in the environment and across food supply chains Near-industrial scale research facilities Water Management and Environmental Risks groups, which are not specifically aimed at agri-tech, but of critical importance to the industry.
University of Essex	Plant productivity, plant physiology, chlorophyll fluorescence measurements and interpretation of data. Plant performance monitoring, crop stress and Spoilage, highly sensitive non-invasive monitoring of plant volatile compounds. Genome wide methods for discovering and exploiting traits for molecular breeding programmes.
University of East Anglia	Water Resources East, a partnership project with Anglian Water, NFU and others - to balance demand and supply for increased agricultural irrigation Water quality – Wensum Alliance – UEA research partnership project with arable farmers in Norfolk Slug it Out – joint UEA research with Anglian Water and with other research institutes: incentivising farmer behaviour to reduce pesticide use

Institution	distinctive strengths
	Soil improvers – UEA research co-designed and applied on a farm scale Weather and climate - Application of UEA-based weather services to improve efficiency of day to day farm activities and longer term planning Innovations in offshore and onshore aquaculture Research on improved feedstock Developing new plant cultivars and manufactured foods to promote health The Overseas Development (DEV) school at UEA also works extensively on food and water as part of their work in developing regions of the World The Adapt Group at UEA runs a venture capital programme which targets the agri-tech sector
University of Hertfordshire	Strong interdisciplinary research collaboration across agriculture and food sciences, engineering and ICT Centre for Agriculture, Food and Environmental Management (CAFEM) - particular strength in applying a life sciences approach to research in arable crops and plant breeding, under climate change, in order to deliver economic benefits to the industry and protect food security. Microfluidics and Microengineering Research Group (MEMS) researching advanced integrated biodefence systems to develop smart bio detection systems that can warn of crop disease risk. The Biocomputation Research Group applying biologically inspired machine-learning algorithms to the analysis of big data, and using genomic databases to create new models that can guide the development of more disease-resistant species of plants and crops
University of Lincoln	Expertise in Robotics (largest agri-robotics team in the World by summer 2017), Engineering, Computer Science, Food Process Technologies. Particular focus on AgriFood could be linked with wider ICT, data and engineering expertise (Cambridge, Agrimetrics, BT Martlesham etc.) to transform the industry in the next 5 years
Royal Veterinary College (RVC)	RVC is a constituent college of the federal University of London. Its Hertfordshire campus is focused on livestock related research and training.
University of Suffolk	Capturing and processing of large scale data sources, analytics and storage. Ecotoxicology – aquatic Diet and Health Ipswich Waterfront Innovation Centre - as a vehicle for prototyping and commercialising research

Source: stakeholder survey responses and web searches

1.17 The region also has Agri-Tech East, the longest established and largest membership organisation and networking body for Agri-tech. It is a commercial organisation, funded through membership subscriptions, event revenues and sponsorship, and is a network bridging academic research with agri-tech enterprise and farmers and growers in the region and beyond. Engagement has focussed on linking R&D with farming and technical enterprises to explore, innovate and create new products aligned with market need. It has increased visibility of activities within the sector and stimulated growth through partnership. Academic centres both in the region and wider UK collaborate at a national level attracting complementary expertise to support innovation. Engagement activities are extended through a suite of events and a leading national conference, as well as close working with members such as the AHDB.

1.18 In addition, many UK national industry representative bodies and industry led research organisations have their base in the region including, for example, the Institute of Agricultural Engineers (IAgri), the Agricultural Engineers Association (AEA), Agricultural Industries

Confederation (AIC), British Beet Research Organisation (BBRO), British Society of Plant Breeders (BSPB), Crop Protection Association (CPA), the Processors and Growers Research Organisation (PGRO) and the UK Irrigation Association (UKIA).

Research funding and outputs

1.19 The following section provides various measures of the scale, quality and results of research on agri-tech undertaken in the region. All of these measures have limitations (for example, there is no way of identifying research quality specifically in Agri-tech due to the RAE subject categorisations, so 'best fit' categories have been used; and patents reflect only a small proportion of commercialisation activity). However, together the tables demonstrate the outstanding scale, diversity and quality of research undertaken in the region and some indication of its commercialisation.

1.20 More detailed information is included in Annex E.

Inputs to research

1.21 Table 1-5 shows that, in terms of number of projects, scale of funding, and share of UK funding, plant and crop science and agri-environmental science are the two outstanding areas of Agri-tech related research in the region.

Table 1-5: Research Council funding in the East of England in disciplines linked to Agri-tech, 2004-16

	Number of projects	Funding (£)	Share of UK projects	Share of UK funding
Plant & crop science	94	41,251,924	30%	35%
Agri-environmental science	88	33,776,526	23%	24%
Ecology, biodiversity & systematics	62	16,553,798	11%	12%
Animal Science	32	13,111,389	7%	7%
Terrest. & freshwater environ.	21	7,549,138	7%	8%
Food science & nutrition	17	5,199,635	20%	16%
Total (all research subject)	**7,119**	**3,530,752,812**	**10%**	**11%**

(Source: Gateway to Research)

1.22 Tables 1-6 and 1-7 provides information on the number of agri-tech research projects led by organisations in the East of England, and the number in which these organisations have participated, based on Gateway to Research data. In terms of research projects led by East of England-based organisations, the data shows a location quotient (LQ) of 1.77, and for participation an LQ of 1.65[21]. This shows that the **East of England leads substantially more agri-tech projects than would be expected in relation to their overall research activity**.

[21] A location quotient shows the relative concentration of activity in an area compared with the national average. An LQ above 1 indicates above average concentration. A full explanation is included in Annex E

Table 1-6: East of England organisations that have led 5 or more Agri-tech research projects

Organisation	Projects led	% of total
Rothamsted Research	210	20.4%
John Innes Centre	178	17.3%
University of Cambridge	162	15.7%
Institute of Food Research	127	12.3%
University of East Anglia	86	8.4%
National Inst of Agricultural Botany	40	3.9%
Babraham Institute	18	1.7%
EMBL - European Bioinformatics Institute	15	1.5%
The Genome Analysis Centre	15	1.5%
University of Essex	11	1.1%
NERC British Antarctic Survey	8	0.8%
MRC Human Nutrition Research Group	8	0.8%
Asymptote Limited	7	0.7%
University of Hertfordshire	7	0.7%
MRC Centre Cambridge	5	0.5%
Total – all projects led	1029	-

Technopolis Group, using gateway for Research data and semantic text analysis powered by SpazioDati

Table 1-7: East of England organisations that have most frequently participated in agri-tech research

Organisation	No. of projects participated in	% of all East of England project participations (n=1,356)
Rothamsted Research	222	16%
University of Cambridge	220	16%
John Innes Centre	189	14%
Institute of Food Research	135	10%
University of East Anglia	109	8%
National Institute of Agricultural Botany	49	4%
Babraham Institute	23	2%

Technopolis Group, using gateway for Research data and semantic text analysis powered by SpazioDati

Outputs from research

1.23 Outputs from research are shown in terms of RAE ranking and patents. Table 1-8 shows that, in terms of 'research power' (quality) rankings, two universities – Cambridge and UEA – are in the top 25 in the country on all three relevant disciplines listed, and in addition University of Hertfordshire is in the top 25 for one of the disciplines.

1.24 In relation to patents (Table 1-9) , the category "analysis of biological materials" has by far the highest number of patents registered, and the region accounts for 14.2% of all UK patents registered in the category

Table 1-8: UK rank on "research power" in disciplines relating directly to Agri-tech

	Agriculture, Veterinary and Food Science	Biological Sciences	Earth Systems and Environmental Sciences
Anglia Ruskin University	-	44	-
University of Cambridge	9	2	8
University of East Anglia	24	20	5
University of Essex	-	34	-
University of Hertfordshire	25	-	-
Writtle College	29	-	-

Source: REF, 2014

Table 1-9: Number of patents registered by inventors in the East of England, in the Agri-tech technology area, 2004-14

	Total number of patents (SIA geography)	Share of UK patents in technology area (%)	Share of all patents in SIA area (%)
Analysis of biological materials	205	14.2	3.4
Environmental technology	44	12.3	0.7
Food chemistry	51	9.9	0.8
Total	**6,005**	**13.7**	**-**

Source: European Patent Office data, PATSTAT

Areas of distinctive expertise

1.25 The stakeholder survey undertaken as part of the process of producing this report revealed a wide range of distinctive areas of expertise in the region, and a very high regard among business respondents for the research institutions and universities in the region. As one consultee put it, "the Eastern region is in a unique position with expertise spanning the full range of Agri-tech from the identification of needs, joint development of solutions and farmscale utilisation". Within this context, the region's most significant and distinctive expertise is in the following areas:

1. **Genomics, Genetics, Agronomy and Plant Breeding:** the region hosts world leading academic research centres whose research outputs directly support major plant breeding, agronomy and agrochemical companies based in the region such as KWS, Limagain, Monsanto and Syngenta. This in turn supports the competitiveness of arable crop production, feed, livestock and food producers. It helps preserve the quality of our agricultural land and reduce the environmental impact of primary food production.

2. **Big data:** the region hosts world-leading research in the capture, processing, management and deployment of big data outputs for Agri-tech applications. This supports the development and integration of new technologies into sensors, machinery and devices (including diagnostics) used in agricultural practice. It generates data that informs agricultural management, protecting yields, increasing

productivity, and reducing energy usage and the environmental impact of agriculture

3. **Robotics and automation:** the region hosts research expertise in robotics, artificial intelligence & soft robotics both in academic research centres and in the engineering and IT sector. This includes the robotics and AI group at the University of Essex, one of the largest groups of agri food robotics expertise in the World at the University of Lincoln, plus the expertise of the University of Cambridge. Key SME's in the region include Dogtooth Robotics developing crop harvesting robotics (funded by the Cambridge Angels), Cambridge Consulting Group, OAL Ltd (food manufacturing robotics), Garford Engineering (robotic weeding technology sold globally) etc.

4. **Nutrition**: the region hosts world leading academic research centres whose research outputs direct the development of primary and secondary food and feed production. This underpins the growth, quality, economic and societal impact of healthy diets, reducing the burden of diet related disease on human and animal health.

5. **Circular bioeconomy:** The East of England is enabling improved sustainability and reuse of primary and secondary outputs of biological production (plants, animals, microbes) for food or non-food end use, as evidenced by research and activities implementing Europe-wide strategic goals. This includes examples of big industry enabling highly efficient use of both feedstocks and outputs; together with small industry activities either individually or in groups. They are both connected to and sometimes enabled by focussed research groups and with structured networking and connectivity initiatives (see case study below).

Case study: examples of the circular bioeconomy in the East of England

Five practical, international quality examples of how the circular bioeconomy is being implemented in the East of England are provided below.

1) Wissington Sugar Beet Factory and processing plant – owned and run by British Sugar:-
this facilities enables close to 100% use or recycling of the sugar beet crop that is grown in surrounding farms. Farmers are contracted to supply sugar beet which are now only sourced within a limited radius of the factory. This ensures that cultivation of this heavy crop, is limited to an economically feasible distance and hence crop transfer miles are minimised.
Once the crop enters the factory it starts on a high tech processing cycle.

- First the soil is washed off the crop – this soil is graded and finally arrives in bagged form ready to sell to farmers and domestic users for top-soil use. The process mitigates soil loss into drainage systems and clogging the local water processing plants
- Next the beets are shredded, tested and processed for the primary product; namely sugar. This is sold as bagged sugar (SilverSpoon) and a variety of food sweetners
- Waste sugar and other bi-products are graded, pelleted and sold in certain high calorie animal feed markets.
- Heat and CO2 from the process is recycled to produce crops in the large glasshouse complex
- High grade products, such as inulin, are removed and go to food and pharmaceutical markets.
- Low grade pulp is transferred to the AD plant and converted to biogas for use in the glasshouses and elsewhere; especially the mushroom farm which delivers a further crop.

2) Development of second and third generation AD plants with attendant innovations from feedstock producers, who provide a range of feedstocks some grown to ensure energy balance (such as maize) combined with other waste material such as livestock waste and vegetable preparation. There is a high concentration of such plants in the region (circa 40) many with specific recycling and bioeconomy objectives driving their original establishment; some specific examples are as follows:

- G's Fresh have set up an AD plant that uses the significant fresh produce waste and 'peelings' produced on site, which could otherwise be wasted or land-filled
- Muntons Malsters have set up a plant to utilise concentrated sugar malt produced in excess of primary malted grain customers. This plant also cleans final water waste to high quality so that it can be recycled to the local river.
- AllPress farms are in the process of commissioning AD for utilisation of fresh produce waste processing (such as leek material) this is processed at their main site near Chatteris ensuring that excess material is no longer transported to the final retail customer, thus reducing fuel waste.

3) Anglia farmers – AF Biomass scheme: this recent initiative set up by Anglia Farmers, enables farmers to use straw from their farms in more useful ways and in a more timely fashion to gain optimal value for soil amendments, AD use or feed; baling, stacking, loading and haulage are all arranged centrally by AF. 55,000 tones of biomass annually and is balanced to provide livestock food; the scheme went into profit last year and significantly reduced waste and improved quality of end products. A new pelleting facility will open in the region within the next 12 months. They also link with sewage processing to use waste straw in water treatment applications. In 2018 linseed straw will be included in the system going into paper industries is the next product that will be added to their portfolio.

4) The new facility run by NIAB at Hassse fen (the East Agri-tech Innovation Hub) is one of the first if not unique initiatives to enable recycling, waste minimisation bioeconomy to flourish in collaboration with small industry and farmers. Our Hub is incubating businesses directly addressing waste reduction through pilot studies and feasibility studies. This is includes the following activities

- Incubation/acceleration of 6 businesses directly on-site and interaction with a further 10 off-site, both large and small.
- International co-operation to kickstart bioeconomy activities via EU funded projects. Bioboost (Acceleration of transition to a bioeconomy in horticulture) an Interreg2Seas project has been set up with UK operations based here. Project budget is 5,873,743 €.
- Training with ARTIS/WRAP/ interaction is being undertaken to transfer knowledge to the farmer community

5) The SME ecosystem is very strong in the region; facilitated by a number of organisations and projects. The subject of bioeconomy and more sustainable production systems is fundamental to many activities by companies in the region. A full list would be very unwieldy but to give a few examples:

- Polymateria; Working on recyclable horticultural protection
- KisanHub; Data driven enterprise platforms for proactive agri-business decisions; mapping geo spatial analytics field sensor deployment, etc
- FarmscanAG; helping farmers via electronics to steer, map, monitor and control spraying, spreading, planting and harvesting machinery
- CropAngel and Hummingbird Technologies: based and/or primarily active in the region; innovative data analytics and artificial intelligence platform for the management of cereal crop health, specifically wheat, barley and oilseed rape.
- uVue Ltd: UAV technology to provide surveillance services to the agricultural sector, using specialist imagery from drones.

Cross cutting: All of these activity areas have been facilitated and are staffed through the strong Agri-tech focussed initiatives and training available in the region. This is supplemented by specific academic, knowledge exchange and networking activities supplied by several organisations and initiatives. These include Cambridge University, University of Lincoln, John Innes Centre, Rothamsted Research, the University of East Anglia, Writtle University College and NIAB at the research end; training facilitated by Easton and Otley College, Anglia Ruskin University; KT and Networking by Agri-Tech East and NIAB Innovation Farm. Demonstration and pilot work at Rothamsted, NIAB Innovation Farm and Eastern Agri-tech Innovation Hub.

1.26 These distinctive areas of Agri-tech expertise are supported by the region's capabilities in various enabling technologies which can be used to underpin existing industries, such as machine learning and AI, data analytics, robotics and sensors. The East of England is extremely well placed to develop and exploit these technologies. This reflects the large concentration of academic expertise within the region, including the University of Cambridge, the excellence and industrial focus of regional Universities and research centres (NRP, NIAB, UEA, Essex, New Anglia, Lincoln, Rothamsted, etc) and the large number of SME technology companies focussing on these technology areas. The growth of these SME's is also facilitated by the concentration of larger national or international end user agriculture and food manufacturing companies located within the region.

1.27 Digital technologies are underpinned by the centre of excellence within the University of Cambridge and augmented by the AI research groups at the University of Essex, University of Lincoln, the Earlham Institute, the Agri Metrics Centre at Rothamsted and the industrial scale of the Tier One ICT providers clustered in the region plus other key technology providers such as ARM Holdings, BT laboratories etc..

1.28 Over the next five years the region will increase the economic impact of these assets through their deployment in three main areas:

1. **Robotics:** the region hosts outstanding research expertise in robotics, artificial intelligence & soft robotics both in academic research centres and in the engineering and IT sector. Mechanisation of agricultural production will be critical to increase labour, crop and livestock productivity and efficiency. In field, this will reduce the requirement for manual labour, increase the efficiency, speed and precision of harvesting, processing and packaging. It will underpin the progression to contained production (vertical farming) for horticultural crops, ensuring continuity and scalable production to meet consumer need. There will be a large skills requirement to enable the industry, both technology developers and end users to adopt new robotic systems.

2. **Rhizosphere modification:** the regional research expertise in microbiology, genomics and agronomy has driven rapid advances in our ability to characterize microbial plant interactions in the rhizosphere. In the next five years the early successes will be translated into new biologics, either microbial inoculum or natural products that will offer environmentally sustainable plant protection and performance products. These will increase agricultural productivity and sustainability.

3. **Sensors and Diagnostics:** genomics has revolutionized our ability to identify and discriminate between microorganisms, pests and plant varieties. The region is a world leader in this emerging technology (pathogenomics). A new generation of sensors and diagnostics are set to transform our surveillance ability, evaluating potential threats from pests and pathogens and directing mitigation.

1.29 These benefits can be delivered by the existing regional assets. The deep science knowledge in data and ICT, **genomics, genetics and plant breeding and microbial research** will act as a foundation for the discovery and translation of technology and innovation. These strengths are complementary. They will drive the development of improved crop varieties fitted for UK production both in field and in emerging contained production systems. Improved varieties

will be developed by regional plant breeding companies, grown by regional farmers and processed to feed and food by one of the region's major industry sectors, food processing.

1.30 This will be complemented by the outputs of plant and microbial research that will generate the **new chemistries (agrochemicals) and microorganisms (biologics)** providing crops with protection from pests and pathogens, increasing nutrient use efficiency (fertilizers) and resilience to environmental stress (temperature and drought) from climate change.

1.31 **New surveillance technologies** arising from advances in genomics linked to sensors and diagnostics will feedback into the development of new resistant varieties and plant protection products safeguarding crop productivity. Collectively these outputs will improve quality and yield, safeguard productivity and reduce environmental impact of agricultural and horticultural production. Improved varieties will play an increasingly important role in improving human and animal health through diet. This will support UK healthcare reducing the burden of lifestyle disease arising from obesity and a high glycaemic index.

Local science and innovation talent

1.32 The region's universities, colleges and research institutes provide a wide variety of education and training focused on agri-tech or closely related areas. This ranges from colleges dedicated to, or strongly focused on, agriculture (e.g. Writtle, Easton and Otley, Oaklands, Shuttleworth) through university undergraduate and postgraduate courses to substantial PhD programmes. However, it is impossible to provide a definitive figure for the scale of education and training in agri-tech undertaken in the region because much of it crosses academic disciplines. Many non agri-tech topics get grouped together in the broad agriculture category used by HESA, and many students in other disciplines across engineering, environment and IT fill jobs in the agri-tech sector.

1.33 Examples from across the region of education and training focused specifically on agri-tech are provided below:

- Rothamsted Research currently has 60 PhD students on site, and plans to increase this to nearer 100, with students are registered at a range of Universities.
- Cranfield University has 70 MSc students a year on agrifood courses, including food chain systems, future food sustainability and applied bioinformatics. It also runs many short courses for professionals, including subjects such as agricultural life cycle assessments, agroforestry for land use intensification, and applied food mycology
- The Department of Plant Sciences in the University of Cambridge contributes to all three years of the Undergraduate Natural Sciences Tripos, and offers postgraduate research and training opportunities in plant and microbial science, including 20 four year BBSRC Studentships in 2017
- NIAB is a partner in the BBSRC Doctoral Training Programme lead by Cambridge University and hosts PhD students undertaking research in crop agronomy and production, crop genetics and pathology
- The Norwich Biosciences Doctoral Training Partnership (DTP) is funded under the BBSRC Doctoral Training Partnership Scheme and was announced in January 2012.

The Norwich Biosciences DTP is one of 14 across the UK and supports over 600 PhD projects across the Norwich Research Park over a three year period. The John Innes Centre is coordinating the programme, which also involves the University of East Anglia, The Sainsbury Laboratory, The Quadram Institute Bioscience (formerly the Institute of Food Research) and The Earlham Institute (formerly The Genome Analysis Centre).

- Hertfordshire Science Partnership will fund 30 PhD researchers in agri-technology and drug development on a new four-year programme towards a 'PhD with Industrial Experience' degree. The funding has been secured by the University of Hertfordshire, including £2.5m from the Hertfordshire Growth Deal via the Hertfordshire Local Enterprise Partnership and £1.5m of ERDF funding

- The Centre for Agriculture, Food and Environmental Management (CAFEM) is a partnership established in 2015 between the University of Hertfordshire, Royal Veterinary College, Rothamsted Research and Oaklands College. It is a virtual Centre with a focus on collaborative research between the partners and delivery of undergraduate and post graduate education.

- The Lincoln Institute for AgriFood Technology (LIAT) is a cross University initiative to conduct post graduate and applied research linked to the agrifood industry. Established in 2015, it has already secured over £15m of industry linked projects with a major focus on automation, water for agriculture and disease prevention and control. LIAT involves over 25% of all staff in the College of Science and runs a new MSc in Agri-Food Technology

- In addition, Lincoln University trains over 230 professional people each year including 24% (c. 50 people per year) of all the BASIS trained students across the UK. This is the basic qualification required by all agronomists to enable them to legally trade (i.e. recommend pesticides to customers).

1.34 There are also examples of apprenticeships at agri-tech education and research institutes, such as the Masterships programmes being developed at Cranfield, and eight apprenticeships at Rothamsted Research organised through Oaklands College.

1.35 In addition to education and training programmes in agri-tech, the region's companies employ a great many people in agri-tech and provide a large amount of on- and off- the job training.

Local industrial strengths and capacities

1.36 Tables 1-10 to 1-12 show that, using a broad definition, ONS data shows that there are nearly 5,400 enterprises employing around 88,000 people in agrifood and food processing in the East of England. Using a narrow definition reduces the number of enterprises slightly to 4,700, but it reduces estimated employment substantially to 57,000. This is because the narrow definition excludes the manufacture of food products and beverages, which tends to be dominated by a small number of large employers. Under both definitions, across the region as

a whole there was a steady growth in enterprises and jobs 2010-15, close to the national average[22].

1.37 The location quotients show a high level of concentration of employment in the region compared to the England average, but an average concentration of enterprises. This suggests that on average Agri-tech enterprises in the East of England are larger than in England as a whole.

Table 1-10: Total enterprises, CAGR for East of England and England (2010 – 2016) and location quotients for SIC codes linked to Agri-tech (agri-food and food processing (broadly defined), agri-food and food processing (narrowly defined))

	Total enterprises	Total employment	CAGR (2010-2016)	England CAGR (2010 - 2015)	Location quotient
Agri-food and food processing (broad)	5,385	88,000	6.1%	8.2%	0.97
Agri-food and food processing (narrow)	4,675	57,000	6.4%	8.8%	0.99

Source: ONS, UK Business Counts – Enterprises (2016)

Table 1-11: Largest, most specialised (by location quotient), and fastest growing (by compound annual growth rate) five districts by BRES employment, with East of England Science and Innovation Audit area and England comparators, for agri-tech 'broad definition' (based on 2012 and 2015 three year rolling averages, i.e. 2010-2012 and 2013-2015)

Largest employment	Most specialised (LQ)	Fastest Growth (CAGR)
South Cambridgeshire (9,800)	South Holland (8.5)	Broxbourne (23.6%)
South Holland (7,200)	South Cambridgeshire (5.4)	Forest Heath (8.4%)
Huntingdonshire (4,300)	East Cambridgeshire (4.7)	St Albans (7.8%)
Cambridge (4,300)	Fenland (4.1)	South Cambridgeshire (7.0%)
Waveney (3,700)	Waveney (3.7)	Breckland (6.9%)
East of England (86,700)	**East of England (1.4)**	**East of England (1.2%)**
England (619,400)	**England (1.0)**	**England (1.3%)**

Source: ONS, Business Register and Employment Survey (2015)

Table 1-12: Largest, most specialised (by location quotient), and fastest growing (by compound annual growth rate) five districts by BRES employment, with East of England Science and Innovation Audit area and England comparators, for agri-tech 'narrow definition' (based on 2012 and 2015 three year rolling averages, i.e. 2010-2012 and 2013-2015)

Largest employment	Most specialised (LQ)	Fastest Growth (CAGR)
South Cambridgeshire (8,900)	South Cambridgeshire (10.0)	Broxbourne (25.3%)
Cambridge (4,200)	East Cambridgeshire (8.8)	South Kesteven (7.7%)
Huntingdonshire (3,100)	Stevenage (3.9)	Forest Heath (7.6%)
East Cambridgeshire (3,100)	Huntingdonshire (3.5)	South Cambridgeshire (7.3%)
Welwyn Hatfield (2,100)	Cambridge (3.4)	Uttlesford (6.6%)
East of England (50,100)	**East of England (1.7)**	**East of England (1.2%)**
England (304,600)	**England (1.0)**	**England (1.7%)**

Source: ONS, Business Register and Employment Survey (2015)

[22] the SICs included in the broad and narrow definitions are included in Annex C.

1.38 Tables 1-11 and 1-12 also show, for both broad and narrow definitions of Agri-tech, the districts with the largest employment, those that are most specialised, and those where Agri-tech employment is growing fastest. Districts in Cambridgeshire, Hertfordshire and the Fens occur most frequently. Both Cambridge – which is almost entirely urban – and South Cambridgeshire are included in the lists, reflecting the concentration of research and technology organisations linked to Agri-tech in and around the city.

1.39 The geographical concentration of employment demonstrated in Tables 1-11 and 1-12 is also broadly reflected in the location of private sector R&D spend, which is spread across the region but is most concentrated in and around Cambridge.

1.40 In addition to analysing the scale and location of employment in Agri-tech in the region it is possible to assess the characteristics and location of the largest Agri-tech companies in the region using Bureau van Dijk's FAME database which is based on information kept by Companies House. A full analysis of this database is included in Annex F, with the following paragraphs providing some summary information.

1.41 Using the broad definition of Agri-tech (including food products and beverages), the top 100 firms in the region (defined by global turnover) have a global turnover worth approximately £2.8 billion. Two thirds are SMEs, 63% are UK owned and two categories, 'manufacture of food products' and 'other professional scientific and technical activities' account for 52% of the firms. Using the narrow definition, the top 100 firms have a global turnover worth approximately £689 million. 83% are SMEs but only 48% are UK owned. 'Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)' and 'Other research and experimental development on natural sciences and engineering' account for over 58% of the firms' activities under the narrow definition. On both broad and narrow definitions, the top 100 companies are distributed widely around the region.

1.42 Considering the strengths of Agri-tech companies in the region in more detail, there are particular strengths in;

- plant breeding – there are 24 plant breeding companies in the East of England, including Germains Seed Technology, LimaGrain, Elsoms, RAGT Seeds, Saaten Union (UK), Floranova. In addition the British Society of Plant Breeders (BSPB) is located in Ely

- agronomy services, agrochemicals and a robust agricultural supply chain - including, for example, Agrii, Hutchinisons, Velcourt, Berry World, Gs Growers, Produce World, Anglia Farmers, FRAM Farmers, CamGrain, Fen Grain, Frontier, AgroVista, 3663 Food Group (Bidvest Foodservice), Sentry Farms, Bayer Crop Science, Briar Chemicals, Dow, DuPont, HL Hutchinson, Monsanto, Syngenta, etc.

- agricultural engineering - including some larger and or very progressive companies such as Cousins of Emneth, GT Bunnings, Standen Engineering, Garford Engineering, Lemken, Lite Trac, PMC Harvesters, Richard Western, Sands Agricultural Machinery, Stocks Ag. The region also has both Perkins Engines, which is a global tractor engine manufacturer, and CNH Tractors in Essex which exports 85% of its output from its 140 acre site, making it a top 10 UK exporter across all sectors

- at the interfaces between Agri-tech and information and communications technology (ICT), robotics, artificial intelligence (AI) and big data. Examples of firms working at these interfaces include Crop Angel (developing drones for practical agricultural applications such as aerial spraying of chemicals), weatherstations (automatic weather station for monitoring weather conditions at own location), Kisan Hub (analyses datasets on farm operations, irrigation, agro-chemical applications, satellite and drone imagery, etc to provide data-driven decision points for farmers), fieldmargin (an app that allows remote farm management), Dogtooth Technologies (building smart autonomous robots for harvesting soft fruits), SmartBell (sensors fitted to animals to detect early signs of sickness) and PBD Biotech (phage-based diagnostic technology in the field of veterinary diagnostics)

- food manufacturing and processing - ranging from major multi-nationals and well known regional brands to small niche producers. Examples include: 2 Sisters Food Group, AB Inbev UK ltd, ABF (Associated British Foods), Adnams, Albert Bartlett, Bernard Matthews, Anglia Malting Ltd (Ragleth Ltd), Arla Foods, British Sugar, Britvic, Coca Cola Enterprises Ltd, Colman's, Fenmarc, Frank Dale Foods, Greencore Group (UK Convenience), Greene King, Greenery UK ltd, Heinz Frozen and Chilled Foods ltd, Hilton Food Group PLC, Kerry Foods (Kerry Group), Kettle Foods, Kinnerton Confectionery, LifeCrown Investments Limited, MBM Produce Ltd, Mars UK Ltd, McCains, MM UK Ltd, Muntons PLC, Pasta Food ltd, Pauls Malt ltd, Pinguin Lutosa Foods UK, Premier Foods, Princes, Smithfield Foods Ltd, Jordans and Ryvita Company ltd, Total Produce Ltd

1.43 Links between industry and the research base are being strengthened further. Examples include:

- the new Innovation Hub, managed by NIAB at Hasse Fen near Soham, which is dedicated to reducing crop and food waste or channeling that waste into higher grade end products. It also works on improving resource use efficiency in the horticultural and fresh produce supply chains. The Hub, which is the first of its kind in the UK, is equipped to run as a field/test station, where NIAB can work with local and national businesses to carry out commercial scale pilot studies. The aim is to increase productivity and reduce crop wastage along the value chain, especially before produce reaches the processor and retailer.

- AgRIA, a trend-setting Agricultural Research and Innovation Accelerator supporting up to 21 innovation projects over a period of 6 to 18 months and involving academics and businesses. Through a physical hub at Rothamsted Research, AgRIA will provide research and innovation mechanisms for SMEs, drawn from multiple sectors, to co-create solutions to problems in agri-food alongside experts from three leading scientific institutions. AgRIA will make a strong contribution to the Hertfordshire Enviro-Tech Enterprise Zone and help develop the next generation of entrepreneurs; potentially bringing new products to market, creating new spins-offs, increasing SME competitiveness and establishing new links between business and research.

1.44 Early stage businesses (start-ups and SMEs) are implementing these innovations for agricultural applications including precision agriculture (KisanHub, uVue, Blue Bear),

harvesting automation, soft robotics (Dogtooth) and contained/urban farming (GroPod, Aponic, Leaf Systems International)[23].

National and international engagement

National

1.45 Agri-Tech East is a commercial organisation, funded through membership subscriptions, event revenues and sponsorship, and is a network bridging academic research with agri-tech enterprise and farmers and growers in the region and beyond. Engagement has focussed on linking R&D with farming and technical enterprises to explore, innovate and create new products aligned with market need. It has increased visibility of activities within the sector and stimulated growth through partnership. Academic centres both in the region and wider UK collaborate at a national level attracting complementary expertise to support innovation. Engagement activities are extended through a suite of events and a leading national conference, as well as close working with members such as the Agriculture and Horticulture Development Board.

International

1.46 Academic research organisation within the region have global reach, both through training of international students and collaborative research. For example, the John Innes Centre has formed a partnership with two institutes of the Chinese Academy of Sciences to establish the Centre of Excellence for Plant and Microbial Science (CEPAMS) in Shanghai[24], and Rothamsted Research has long-established links with developing countries.

1.47 Government funding (BBSRC, Newton and Global Challenges Research Funds) has enhanced international collaboration and extended that established through the EU (Horizon 2020, ERC). Academic international partnerships and relationships are increasingly supporting the development of commercial opportunities for regional Agri-tech companies. In addition, local authorities within the region have established "twinning" with regional Governments overseas, which has increased trade and the potential for collaborative R&D. For example, the twinning arrangement between Essex County Council and Nanjing in China, has helped attract inward investment from China including the Cocoon Investment fund (Adapt Group).

Developments in the wider funding landscape

Investment

1.48 Globally, agri-tech venture capital funding increased during the first quarter of 2017 following a decline in the amount of funding in 2016, despite the fact that there was an increase in both the number of deals closed and the number of investors coming into the sector. The increase

[23]For further information see http://www.AgriTech-east.co.uk/about/publications/
[24] https://www.jic.ac.uk/news/2016/09/launch-joint-john-innes-centrechinese-academy-sciences-shanghai-laboratory-bolsters-uk-china-scientific-collaboration/

in deal activity reflects the growing number of programmes and resources available to startups, including new venture funds, accelerators and incubators. [25]

1.49 Given the small number of dedicated funds, the sector depends on non-agriculture focused investors, at the early stage, but particularly at the later stages. Much of this has come from family offices and big name Silicon Valley VCs. For example, in 2016 Google Ventures made five investments across the sector, all at Series B round, while Khosla and Kleiner Perkins, Caufield & Byers both made three each.

Investment by category – global picture[26]

1.50 Despite a number of challenges for startups in the **Food Marketplace/Food E-Commerce category**, it continued to dominate global Agri-tech funding during 2016, accounting for 40% of total funding and $1.29 billion in investment

1.51 **Biotechnology** startups serving the agriculture sector collected the second largest portion of funding with 22% of funding and $719 million across 84 deals. Crop technologies dominated the category, raising $523 million across 61 deals. Of these, 22 were researching the microbiome for biological products and three were using gene-editing technologies.

1.52 Investment in **precision agriculture technologies**, which include data-capturing devices and farm management software showed a 39% decline on 2015. In contrast, investment in **Novel Farming Systems**, which are startups using new and innovative ways to produce agricultural and biological products, increased in 2016.

UK funding

1.53 Research published in July 2016 on public and private sector investment in agri-tech R&D[27] shows that public sector investment in 2012-2013 was £320M, and the private sector investment was £496M. BBSRC accounted for 51% of the public sector spend (31% research and 20% capital), with DFID and Defra accounting for a further 29%. Of the private sector spend, 78% was by 10 large companies (over 1000 employees), and 83% was by multinational companies.

1.54 The amount of government funding for Agri-tech has been increasing and take up has been very good. The Catalyst fund (£60m is now fully committed), The SAFIP programme (£90m) is fully spent. In addition, SARIC, CIRC, HAPI are industry linked programmes with government and industry funding which have been fully subscribed, and IUK has run specific calls for agri-tech each year since 2013 (each circa £10-15m) all of which have been fully spent.

1.55 The sector has also been successful in H2020 at UK level. The UK leads 2 out of the 17 Thematic Networks for agri-tech the EU has so far set up.

[25] https://agfunder.com/research/agtech-investing-report-2016, and CB Insights Agritech Market
[26] https://research.agfunder.com/2016/AgFunder-Agtech-Investing-Report-2016.pdf
[27] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/536414/bis-16-17-private-and-public-sector-funding-of-agritech.pdf

Regional funding

1.56 The East of England benefits from access to Europe's main centre for VC funding, London. In addition, Cambridge also has one of the strongest VC and seed fund sectors outside London, including the likes of Amadeus Capital, Cambridge Capital Group and the Cambridge Angels. There are also several funding sources more specifically focused on the agri-tech sector in the East of England, including:

- the Eastern Agri-Tech Growth Initiative, a £3.2m fund which provides grants of between £10,000 and £150,000 to businesses based in Cambridgeshire, Peterborough, Norfolk, Suffolk, Rutland, North Hertfordshire South Lincolnshire, or Uttlesford. The funding has been provided by the Government's Regional Growth Fund and is divided into two parts; the Research, Development and Prototyping fund supports R&D of new products or processes with grants of between £10,000 and £60,000 and the Growth fund offering grants between £25,000 and £150,000 to support product development and improve agricultural productivity. To date, 65 grant applications have been approved, including food and drink producers and growers, bespoke equipment and chemical manufacturers and innovative IT companies who supply to the agricultural sector[28]

- Cambridge Agritech, a syndicate composed mainly of private investors who are either owners or directors of some of the largest food and agricultural businesses in the UK. They invest in innovative SMEs in the agricultural sector in Europe and the US[29]

- the Agri-Innovation Venture Capital Fund, launched in 2014 as a co-investment pot in response to the recognised need for investment into early and medium stage agri-tech enterprises in the UK. It was operated by the Adapt Group at the University of East Anglia in concert with the Tsukuba Technology Seed Co Ltd (TTS) in Japan, but is now on hold.

- Adapt Cocoon, a joint venture between the Adapt Group at the University of East Anglia and Cocoon Networks, Europe's largest start-up ecosystem backed by Chinese capital. The focus is on UK-based Green-Tech companies with growth potential in the Asian markets.

- Anglia Capital Group, a group of Angel Investors who invest in start-ups and early growth-stage businesses with innovative and potentially disruptive technology at their core. New Anglia Local Enterprise Partnership has co-invested with Anglia Capital Group to support agri-tech deal flow.

Conclusions – and future potential

Opportunities

1.57 Opportunities for future growth of Agri-tech in the region, identified by business respondents to the stakeholder survey and summarised in Table 1-11, reflect the significance of the

[28] http://www.gcgp.co.uk/agri-tech-grants/
[29] https://www.camagritech.com/about.html

interface between new information and engineering technologies and Agri-tech, described in previous sections.

Table 1-13: Opportunities identified by Agri-tech businesses in the East of England

Engineering, data and IoT is expanding globally at circa 10-15% per annum CAGR, and is already worth nearly half of the total Agri-tech market.
Information technologies will enable precision agriculture. Sowing, watering, fertilising and harvesting will all be computer-controlled, consequently more efficient, less wasteful, more productive
Convergence of technologies through ICT and Engineering, such as smart sensors and biodetection, will enhance the region's expertise in precision crop agriculture/horticulture.
Increased automation to boost productivity of the agri-food sector while maintaining high sustainability standards and low environmental impact
Reducing crop losses and waste through smart crop protection and nutrition, whilst enabling growers to reduce input costs and to reduce environmental impact
Increase the value of primary agricultural outputs retained by the growers and processors in the region
Maintain and improve the soil to enable crops to achieve higher yields to feed a growing population

Source: Agri-tech stakeholder survey

1.58 Specific examples of the economic impact of new engineering and informatics technologies include the automation of contained and peri-urban/contained horticultural production. UK horticulture has the potential to provide far more of the UK's demand for fresh produce throughout the year, independent of seasonality. This potential can only be realised through science and innovation that delivers automated (planting, growth, harvesting and packaging), energy efficient contained production (LED and aeroponics) and new horticultural varieties bred for quality (nutrition) and consumer traits. Demonstration of large-scale production of high value crops will drive investment and growth.

1.59 In parallel innovation in robotics, artificial intelligence and soft robotics will deliver new automated systems for precision farming. Increasing efficiency in agricultural production will drive (and fund) the uptake of new field crop varieties, biologics and natural chemistries. These will further increase yield, quality, resilience and sustainability.

1.60 Collectively this will have a major impact on economic development across agriculture, horticulture, feed and food processing. It will generate new high tech jobs in technology development, manufacturing, technology implementation and maintenance. It will lead to upskilling in farming and horticultural production. Further, it will create new export opportunities for manufacturing and technology implementation.

1.61 There are local, national and international markets for these innovations. These opportunities can be realised through cross cutting research and development.

Gaps

1.62 Gaps in support which may constrain future growth of Agri-tech in the region, identified by business respondents to the stakeholder survey and summarised in Table 1-12.

Table 1-14: Gaps identified by Agri-tech businesses in the East of England

Better transport and internet connectivity otherwise people cannot commute nor work from home. It's really fundamental but sadly overlooked and will be the downfall of UK innovation.
Need for more investment in practical research projects which improve crop yields while also ensuring that the environment is protected (sustainable intensification)
Need to invest in human and physical assets in place to exploit the opportunities created by digitally enabled technology for agriculture and the food chain
More resources need to be focused on networking industry and research. There are still too many scientists not talking to industry and too few industry members talking to scientists. Unless this is addressed the challenge will not solved
More collaboration with education and research bodies and commercial sector in order to close the commercialisation gap
Further investment across all academic institutions within the region to ensure that there is a continuum from exploratory research to application
Need for more support to start ups and extension support to get new automation technologies adopted on farms
Paucity of availability of small, easy access, wet lab/glass house/kitchens/field plots/maker spaces/small engineering laboratories

Source: Agri-tech stakeholder survey

1.63 There are clearly some concerns about focusing research on key commercial opportunities, and the commercialisation capacity in the region. However, the most important message from the survey was the outstanding economic potential of the research undertaken in regional institutions, and the need to strengthen mechanisms to realise that potential for the benefit of the region and the UK.

1.64 There are already some important assets to support innovation and commercialisation in the region. For example, Agri-Tech East supports business networking where innovation is made visible and approachable to the sector. The comments suggest that there is a strong argument to increase its capacity. However, the region lacks the strong investor base to drive the establishment and growth of new innovative companies and there is a shortage of CEO's with sector experience. The investment issues could be addressed in two ways:

- government support to encourage/ incentivise risk capital for early stage investment in Agri-tech businesses and through seed funding within the academic research centres. These should be linked to business professionals providing oversight to investments and business support, and modelled on the success in life science commercialization
- increasing the uptake of grant funding by Agri-tech businesses. Understanding the barriers is critical to increasing sector R&D activity. Long timescales for return on investment combined with the low margins on primary agricultural sales may be contributing factors.

1.65 DARPA style initiatives for multidisciplinary consortia (academia and industry) could stimulate innovation to address key challenges. Initiatives could include: 1. in robotic automation within in-field agricultural and horticultural production; 2. robotic automation within contained horticultural production; 3. big data management and integration in disease and pest surveillance and crop management; 4. Plant breeding, biologics and agronomy for

improvement in crop quality (nutrition), crop health (mycotoxin) and resilience (climate change).

Interventions

1.66 The hypothesis that was to be tested in relation to Agri-tech was

The region has world-renowned research strengths in Agri-tech, and increasing expertise and experience in the process of commercialisation. Further strengthening of the mechanisms for commercialisation will bring major economic benefits to the region and to the national economy.

1.67 We believe that this SIA has demonstrated that the region has world renowned research strengths in Agri-tech, and considerable strengths in commercialisation. Below we make various proposals for interventions which should further improve the processes and effectiveness of commercialisation in the region. We are confident that, with the outstanding science and innovation assets in the East of England, these interventions will bring major economic benefits regionally and nationally.

1.68 The region's current strengths in Agri-tech science and innovation come from a strong science base through its universities and research institutes, its diverse and internationally connected industrial base and from its importance as an area of World leading agricultural productivity.

1.69 These factors will continue to be important in the future, but as the world of agriculture is driven by economic, environmental and societal factors towards smarter precision based production, those who deliver science and innovation in Agri-tech must be able to deliver solutions appropriate to these needs, and as a region, the East of England must be conducive to such delivery.

1.70 The region will seek to make interventions which align its research and commercial strengths with the growth in global markets. This includes supporting inter-disciplinary innovation which draws on enabling technologies from other sectors in which the region is strong e.g. ICT and by linking its expertise in Agri-tech to high value end use markets where the region also has commercial and research strengths such as life sciences.

1.71 The interventions are structured to give a balanced portfolio of:

- Continued investment in new areas of physical infrastructure to expand the region's capability so that it can exploit the opportunities in new growth markets;
- Increased investment in the existing networking activities between research and industry to improve the promotion of existing innovation assets and to support enhanced collaborative working;
- Supported by more local autonomy and direction over the allocation of innovation support to promote collaborative work between industry and research to commercialise new products and services for the Agri-tech market.

1.72 The interventions are described below. Summary business cases, which follow the structure specified in the SIA Guidance, are included in Annex D.

Physical Infrastructure for new areas of Agri-tech

1.73 The region's strengths will be enhanced by supporting the development of new infrastructure to facilitate the region's move into new innovation areas to grow the resources available to support Agri-tech companies. This will add significantly to the existing centres of Agri-tech innovation in Norwich, Harpenden, Cambridge and Cranfield.

1.74 The major developments in the pipeline include:

- Hinxton Park for Agri-tech, which is planned to create an international business park focused specifically on the Agri-tech sector in the heart of the science park cluster South of Cambridge. This will draw on the region's World leading research and industrial base to host companies working on precision agriculture and associated technology;
- Holbeach Centre for AgriFood automation on the Holbeach Food Enterprise Zone, which will build on the Lincoln Institute for AgriFood Technology and National Centre for Food Manufacturing, to develop a national centre for food chain automation focused on promoting enhanced labour productivity through automation and robotics
- A Microbiome Innovation and Knowledge Centre, to commercialise emerging technologies related to the microbiome (including human and animal gut microbiome, skin microbiome and soil/plant microbiome) at Norwich Research Park[30]
- The Quadram Institute, which will open in 2018 and will provide a national centre of research excellence for understanding how food and the gut microbes interact.

1.75 Both new centres build on existing regional strengths in the food chain and capabilities from the ICT, engineering and digital industries in which the region has World class expertise. They also respond directly to the large growth in global demand for sensors and engineering which together account for nearly 50% of the global Agri-tech market, estimated at £142billion in 2012[31].

Improved Networks

1.76 Through its research institutes and universities, science in the region is strong and this strength will be used to foster research in its Agri-tech companies. To ensure the region derives maximum benefit from its existing science and innovation base, it must ensure effective integration within the science community and between the science community and industry.

1.77 Further collaboration between existing centres and industry will enable the region to develop more economic output from the sector and to project its expertise more strongly at the global level to attract further inward investment.

1.78 To achieve this we must:

[30] Note: the details of this project are included under the Life Sciences theme.
[31] UKTI (2013), AgriTechnology Sector: Market Trends and Opportunities Report

- Enhance networking between the stakeholders across industry, research and economic policy. It is widely agreed that Agri-tech East has added significantly to networking of the region's Agri-tech community since its creation. This gives us a starting point and a base on which to build, but further investment into Agri-Tech East is needed to broaden and deepen the collaboration potential which this has begun to unlock.

- Support the continued integration of the new UK Centres for Agricultural Innovation, created as part of the delivery of the UK Strategy for Agricultural Technologies. All four of these new centres are represented in the region, but we need to work on how they can be more effectively linked into the region's existing Agri-tech innovation centres and commercial companies.

1.79 There are three thematic areas in which the region has existing strengths which would benefit from improved networking and more collaborative working. These are:

- **Plant sciences** - the region has World class depth and breadth in plant sciences with the John Innes Centre and Sainsbury Laboratory ranked first globally in this sector, Rothamsted Research, Cambridge University and NIAB all recognised as globally important institutions, as well as many pockets of research in other Universities and numerous plant science focused companies in the region. At present there is little co-ordination of this breadth of expertise and marketing and outreach efforts tend to be conducted by each centre on its own.

  Working to promote this plant science base collaboratively would reinforce the region's position as the go to place for plant science innovation in Europe. Collaboration in developing major projects and investment propositions to support global plant science companies in expanding or developing their presence in the region would deliver significant growth potential and create the market pull to justify further investment in the research base.

- **Data Analytics for Research and Industry** - the importance of data intense activities, 'big data', in agriculture and agricultural science is growing and this will continue. Existing expertise includes computing at many Universities across the region with particular strengths allied to life sciences in Cambridge, the UEA and at the Earlham Institute. The global BT R&D HQ in Martlesham and the cluster of ICT companies at Adastral Park also compliment the more specialist agriculturally focused ICT sector. The region has also seen several new Agri-tech data companies formed, particularly in the Cambridge sub-region. To continue to grow its strength in data analytics the region must have the infrastructure and expertise necessary to facilitate future data intense research and the use of data in agriculture. To achieve this we must:

  - Invest in the work of the AgriMetrics Centre based at Rothamsted and in which NIAB is a partner to develop the region's position as the national centre of data analytics for agriculture;

- Work in close collaboration with the ICT sector in the region to ensure that the development of a regional ICT platform for science and innovation is aligned with the needs of Agri-tech.

- **The Circular Bioeconomy -** agriculture and the food chain it supplies has a significant impact on the environment and has therefore been a focus for global efforts to reduce overall environmental impact. As the environmental solutions sector matures, the market for new and existing circular economy businesses will grow significantly. Importantly, this growth will be greatest in the area of improved use efficiency, by deriving value from co or by products which have often previously been seen as "waste". UK development of this sector has tended to focus on low value, high volume uses of biomass such as bioenergy, but future development must also build on the work which started with the InCrops project in the region between 2008-15 to develop higher value end uses such as bio-fabrics, biomaterials, bio-chemicals and bio-lubricants. Global growth in this sector is supported strongly by policy at the UK and EU level. It is therefore important that the region stays at the forefront of this field. To achieve this we must:

  - Support our science base to deliver the solutions needed for the achievement of a successful circular bioeconomy, targeting in particular higher value end uses;
  - Support business growth in the bioeconomy;
  - Support the continued growth of key infrastructure to support companies such as the bio-refinery team at the Quadram Institute and Hasse Fen unit of NIAB which are working in this field.

Delivering Innovation Support in Business

1.80 The Agri-tech sector is focussed on delivering real solutions for the agri-food sector which can deliver growth by delivering new products and services to expanding markets in the UK and globally.

1.81 Whilst the East of England has begun to expand its commercialisation work in the Agri-tech sector our record in technology and knowledge transfer can be improved to help the region fully exploit the potential which exists in its Agri-tech science and innovation base. This commercialisation gap exists well beyond the East of England, but our strengths in Agri-tech science, innovation and the industrial base means that we are well placed to lead the World in closing this gap.

1.82 To achieve this we must:

- Create a science and innovation infrastructure that works for both research and business;
- Develop and attract the talent that can deliver Agri-tech innovation, including through supporting student start ups and spinouts;

- Foster the creation and growth of new Agri-tech businesses in the region through targeted business support through the LEP Growth Hubs and sector groups as Agri-tech East.

1.83 One specific action which would help support all these objectives would be to have more regional autonomy over the allocation of innovation funding. The experience with ERDF and the very specific Eastern Agri-tech Initiative funding administered by GCGP and New Anglia LEPs, shows that there is demand in the region for locally directed funding to support Agri-tech innovation and deployment.

1.84 Furthermore, in delivering the second major intervention theme proposed, on networking the Agri-tech sector, the availability of locally responsive, targeted innovation funding which can be allocated quickly and efficiently to the sector, can have a significant impact on commercialisation rates. This could include small grants to encourage large companies that have high innovation capacity to "incubate" start-ups and spin-outs and host research projects.

1.85 The region also has access to a strong Venture Capital (VC) network in Cambridge and a developing network in Norwich, which have recently started to target the Agri-tech sector. These VC networks bring business start up expertise and mentor companies as well as providing risk capital.

1.86 Nurturing this emerging private equity investment interest in the sector, coupled to flexible local innovation funds, business support and networking would help to facilitate more Agri-tech spinouts and start ups in the region.

Links to other themes

1.87 Key strands of Life Science connecting to Agri-tech include genomics, food and the microbiome. For example:

- Development of new crop types e.g. pesticide, salt and drought tolerant strains to increase efficiency and maintain output in response to environmental changes.
- Control of plant diseases to improve productivity.
- Development of pest control systems.
- Understanding of plant nutrient systems.
- Driving accelerated innovation of food and related products and therapies to address major health issues.

1.88 There are strong connections between ICT and Agri-tech , for example:

- Data processing and visualisation expertise can be applied to data collected from GPS controlled farm machinery, to inform individual farm actions to increase efficiency and at a regional scale to understand response to weather and climate.
- Use of drones and remote sensing to record crop health and deliver targeted nutrients and irrigation.

- Robotic and automated systems are very dependent on sensors, vision systems and data processing to collect, process and interpret their surroundings so that they can operate safely and efficiently.
- A lot of Agri-tech advances are highly dependent on internet connectivity and the Internet of Things (IoT) is beginning to be exploited in the sector.

1.89 In relation to Advanced Engineering and Materials, there are also many important links, for example in relation to tools for precision agriculture, sensors for agriculture and robotic and autonomous systems. Crossover between the themes is illustrated by one of the largest groups of agri food robotics expertise at the University of Lincoln, and by the AgriEPI Centre based as Cranfield which provides a route to interacting with other sectors in the engineering space, such as Aerospace and Earth Observation, Automotive, High Value Manufacturing, Photonics and Through-life Engineering. There are also various SME's in the region which operate at the interface between Agri-tech and other technology areas such as Dogtooth Robotics (developing crop harvesting robotics), OAL Ltd (food manufacturing robotics) and Hummingbird Technologies (UAV's and AI).

Annex A: Contributors and Consultees

Table A-1: Organisations responding to the stakeholder survey

Organisation	Person and position
University of Cambridge	Kate Parsley, Impact Facilitator
University of Cambridge	Dr Mariana Fazenda, Innovation & Enterprise Project Officer for the Department of Plant Sciences
Cranfield University	Joanna Cox, Head of Business Partnerships
University of East Anglia	Dr Ruth Welters, Relationship Manager (Environment, Agriculture and Marine)
University of Essex	Kirstie Cochrane, Knowledge Exchange Manager
University of Hertfordshire	Dr Phil Fiddaman, Deputy Director of Business Development
University of Lincoln	Professor Simon Pearson
University of Suffolk	Stefanie Thorne, Head of Research and Enterprise Services
Collison Associates Ltd	Martin Collison, Director
DuPont	Mike Ashworth, Fungicide Product Manager
Fram Farmers Ltd	Richard Anscombe, Chief Executive
H L Hutchinson	Dr David Ellerton, Technical Development Director
Produce World	Andrew Burgess, Owner

Table A-2: Other contributors and consultees

Organisation	Person and position
Agri-Tech East	Belinda Clarke, Director
John Innes Centre	Jonathan Clarke, Head of Business Development
Innovate UK Knowledge Transfer Network	Liliya Serazetdinova, Knowledge Transfer Manager, AgroFood

Annex B: Definition of Agri-tech

AgriFood Technology Leadership Council Definition of Agri-tech [32]

The farming industry, including diversified activities such as on-farm waste and biomass (grass, energy crops, specialist crops) for non-food uses.

Plant subsectors (crops including cereals, oilseeds, pulses, forage, potato, sugar beet, vegetables, salads, mushrooms and fruit) including:

- Plant genetic improvement: genetics, genomics, biotechnology, breeding/ propagation, genetic conservation
- Plant health: plant production (physiology, agronomy, crop management and nutrition such as fertilizer/ agri-chemicals) and plant protection (identification, diagnostics, epidemiology , management / control including biological controls / vaccines / therapeutics of pest disease and weeds)
- Crop storage and silage (including post-harvest storage and on-farm waste and biomass for non-food uses)

Animal subsectors (livestock: dairy, beef, sheep, pigs, poultry (egg and meat) and aquaculture for fish: salmon, trout, shellfish) including:

- Animal genetic improvement: genetics/ genomics; breeding/reproductive technologies; genetic conservation
- Animal nutrition, including ingredients for animal feed; grazing systems and pasture diversity
- Animal health and welfare (endemic diseases, exotic diseases, behaviour): identification, diagnostics, epidemiology, management / control, vaccines, therapeutics, surveillance; building and environmental design to reduce stress and promote welfare

ICT systems and decision support: to support production planning, scheduling; input use efficiency (e.g. irrigation scheduling)

Environmental and physical subsectors including:

- Soil/ substrate management: soil physics, biology and chemistry, soil amendments (e. g. biosolids, AD digestates, water retention gels etc.); controlled traffic farming; reduced ground pressure; soil sampling; soilless growing media (glasshouse crops)
- Environmental interactions (air, water, biodiversity – plant and animal; ie. technology / decision support tools to improve animal welfare & environmental outcomes including reducing air and water pollution, greenhouse gas emissions including quantity and quality of air and water)
- Harvest and early-stage processing including harvest technologies, post-harvest cleaning, postharvest storage (chemicals and storage conditions), on-farm waste (AD and other waste treatment plants) and biomass for non-food uses

Engineering and precision farming, including machinery (cultivation, crop and grass health (drilling, spraying, fertiliser application), tractors, harvesters, pickers, post-harvest transport and cleaning), robotics including GPS applications and autonomous devices, sensor technology (hand held, fixed and remote including animal welfare and monitoring)

Infrastructure: buildings (including glasshouses, livestock production buildings), heating and cooling systems, storage of crop and animal products in ambient, controlled atmosphere, cold stores and freezing plants, irrigation/ water management storage and distribution systems, dirty water systems, lighting (intensive livestock and glasshouse crops); 'vertical' and enclosed farming systems

Advisory services

[32] BIS RESEARCH PAPER NUMBER 284 (July 2016), Agri-Tech Industrial Strategy: Evaluation Scoping Study and Baseline

Annex C: SICs included in broad and narrow definitions of Agri-tech

Agri-tech (Broad)

C.1 Defined to develop a broad account of agri-tech and related activity covering agri-food and drink manufacturing and production, and food processing.

Table B-1: Agri-tech broad definition

SIC code (2007)	
0164:	Seed processing for propagation
2015:	Manufacture of fertilisers and nitrogen compounds
2651:	Manufacture of instruments and appliances for measuring, testing and navigation
2222:	Manufacture of plastic packing goods
8292:	Packaging activities
7219:	Other research and experimental development on natural sciences and engineering
74909:	Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)
10:	Manufacture of food products
11:	Manufacture of beverages
202:	Manufacture of pesticides and other agrochemical products
283:	Manufacture of agricultural and forestry machinery
712:	Technical testing and analysis

Agri-tech (Narrow)

C.2 As per agri-tech (broad) but with SIC codes 10 and 11 removed to narrow the inclusion of 'pure' manufacturing jobs.

Table B-2: Agri-tech narrow definition

SIC code (2007)	
0164:	Seed processing for propagation
2015:	Manufacture of fertilisers and nitrogen compounds
2651:	Manufacture of instruments and appliances for measuring, testing and navigation
2222:	Manufacture of plastic packing goods
8292:	Packaging activities
7219:	Other research and experimental development on natural sciences and engineering
74909:	Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)
202:	Manufacture of pesticides and other agrochemical products
283:	Manufacture of agricultural and forestry machinery
712:	Technical testing and analysis

Annex D: Detailed data on publicly funded research activity in agri-tech in the East of England

D.1 This document was produced by Technopolis as part of their analytical support to the SIA. It summarises the level and scale of publicly funded research activity taking place in Agri-tech within the East of England SIA area. It also seeks to identify which organisations are most frequently engaged in Agri-tech research within the area.

Methodology

D.2 The analysis focuses on:

- Data from the Gateway for Research: this includes most R&D activity funded by the UK research councils, but also grants from InnovateUK. The data will therefore include not only research grants but also feasibility studies, pilots, prototypes and proof of concepts, knowledge transfer networks and innovation voucher grants amongst others.
- Data from the 7th EU Framework Programme 2007-2014 and Horizon 2020 2014-2016 (comprising blue-skies research funded by the European Research Council, down to feasibility studies from SME-Instruments grants or projects in the context of public-private partnership in research).

D.3 Using specialist software, we have a run a semantic text analysis of the titles and abstracts of each project/activity to identify **Agri-tech related research.**

D.4 Using this tool we have mined 100,000 projects and have identify those that have a series of key word and phrases relevant to Agri-tech. It also looks for relevant phrases and concepts associated with the key words, as well as synonyms and technical names for the phrases/concepts being studied.

D.5 To analyse strengths in Agri-tech research we use location quotients (LQs). LQs provide a way of demonstrating whether the East of England has a higher concentration of research activity in Agri-tech related research relative to the UK average. A more detailed explanation on how we derive LQs is provided in Appendix A. In short however, an LQ of 1 indicates that research activity for a given topic is as heavily concentrated in the East of England as it across the UK overall. An LQ greater than 1 indicates that a given topic accounts for a larger share of all East of England research activity than would be expected when compared to the UK average. In other words, LQs substantially greater than 1 signals a level of activity/specialisations that exceeds what would normally be expected nationally.[1]

Analysis of research activity

Gateway for Research (national research activity)

D.6 The analysis of GtR shows that the East of England is a very active player in research centred on Agri-tech. In terms of research projects led by East of England-based organisations, the data show an LQ of 1.77, reflecting that the **East of England leads substantially more agri-tech projects than would be expected in relation to their overall research activity**. Table D-1 below provides a more detailed breakdown of the East of England-based organisations that have led Agri-tech research projects. As shown, Rothamsted Research is the lead organisation for 20% of the Agri-tech research projects based in the SIA area. The John Innes Centre, the University of Cambridge, and the Institute of Research also lead a comparatively large number of projects and taken together with Rothamsted, the four account for two-thirds (66%) of Agri-tech project leads in the area.

Table D-1: East of England organisations that have led 5 or more Agri-tech research projects

Organisation	Projects led	% of total
Rothamsted Research	210	20.4%
John Innes Centre	178	17.3%
University of Cambridge	162	15.7%
Institute of Food Research	127	12.3%
University of East Anglia	86	8.4%
National Inst of Agricultural Botany	40	3.9%
Babraham Institute	18	1.7%
EMBL - European Bioinformatics Institute	15	1.5%
The Genome Analysis Centre	15	1.5%
University of Essex	11	1.1%
NERC British Antarctic Survey	8	0.8%
MRC Human Nutrition Research Group	8	0.8%
Asymptote Limited	7	0.7%
University of Hertfordshire	7	0.7%
MRC Centre Cambridge	5	0.5%
Total – all projects led	1029	-

Technopolis Group, using gateway for Research data and semantic text analysis powered by SpazioDati

D.7 Table D-2 shows that the East of England's credentials are equally strong when it comes to participating in (rather than leading) UK funded Agri-tech projects. The LQ of 1.65 indicates that the concentration of research involvement in the East of England is substantially higher to their overall research activity.

Table D-2: LQs for East of England organisations' participation in national research projects (compared to the UK picture)

Activity area	Projects where East of England organisations have participated	All projects in the UK	East of England as % of UK total	LQ
All sectors and themes	10,064	68,324	14.7%	-
Agri-tech	1,356	5,574	24.3%	1.65

Technopolis Group, using gateway for Research data and semantic text analysis powered by SpazioDati

D.8 Table D-3 below sets out the East of England organisations that have most frequently participated in Agri-tech research projects. As shown, the list is comparable to that of the projects led (see Table D-1) with Rothamsted Research, the University of Cambridge. The John Innes Centre, the Institute of Food research, and the University of East Anglia being the institutions most commonly involved in Agri-tech projects. Other East of England participants however, include Schlumberger Cambridge Research (involved in 17 projects), the University of Essex (involved in 13 projects), and RAGT Seeds (involved in 7 projects).

Table D-3: East of England organisations that have most frequently participated in agri-tech research

Organisation	No. of projects participated in	% of all East of England project participations (n=1,356)
Rothamsted Research	222	16%
University of Cambridge	220	16%
John Innes Centre	189	14%
Institute of Food Research	135	10%
University of East Anglia	109	8%
National Institute of Agricultural Botany	49	4%
Babraham Institute	23	2%

Technopolis Group, using gateway for Research data and semantic text analysis powered by SpazioDati

Framework programmes FP7 and H2020 (European research activity)

D.9 The picture of East of England's involvement in European-funded research is not as favourable as that for UK-funded research. Nevertheless, the data do suggest the SIA area's performance is broadly in line with their overall research activity. For Agri-tech research projects led, the East of England has an LQ of 0.9, indicating that activity levels are slightly lower than, but close to, the UK average.

D.10 As shown below, eight organisations led EU-funded agri-tech research. The University of Cambridge and TWI Limited (based in Cambridge) accounted for the majority of these (c. 70%) although the John Innes Centre was also an important contributor.

Table D-4: East of England-based organisations that have led EU-funded agri-tech projects

Organisation	No. of projects led
University of Cambridge	18
TWI Limited	11
John Innes Centre	7
University of East Anglia	2
The Babraham Institute	1
Ocado Group Ltd	1
Anglia Ruskin University	1
Permastore Limited.	1
Total	42

Technopolis Group, using gateway for Research data and semantic text analysis powered by SpazioDati

D.11 Table D-5 shows that in relation to the East of England's participation in EU funded programme (rather than those it has simply led), the area's relative performance to the UK as a whole is much better. Indeed, with an LQ of 1.03, participation in Agri-tech research is slightly more concentrated than the UK average.

Table D-5: LQs for East of England organisations' participation in EU-funded research projects (compared to the UK picture)

Activity area	Projects where East of England organisations have participated	All projects with UK involvement	East of England as % of UK total	LQ
All sectors and themes	1,800	12,807	14.05%	-
Agri-tech	192	1,324	14.50%	1.03

Technopolis Group, using gateway for Research data and semantic text analysis powered by SpazioDati

D.12 The organisations most commonly involved in these EU-funded projects are very much those also involved in UK-funded ones, as demonstrated by Table D-6. The University of Cambridge and TWI Limited are the two that more frequently engage in EU funded research projects although the University of East Anglia and John Innes Centre are also involved in a large handful of projects each. Other East of England-based organisations engaged in EU funded projects include the Quadram Institute, Cambridge Flow Solutions, and the University of Essex.

Table D-6: East of England organisations that have most frequently participated in EU-funded agri-tech research

Organisation	No. of projects participated in	% of all East of England project participations (n=192)
University of Cambridge	63	33%
TWI Limited	21	11%
University of East Anglia	12	65
John Innes Centre	11	6%

Technopolis Group, using gateway for Research data and semantic text analysis powered by SpazioDati

Summary

- In comparison to the UK as a whole, the East of England has a considerably higher than average concentration of research activity in Agri-tech. Rothamsted Research and the John Innes Centre have the greatest tendency to lead East of England-based projects. The University of Cambridge, The Institute of Food Research, and the University of East Anglia are also amongst the most frequent participants in agri-tech projects.

- In relation to EU-funded projects, the concentration of East of England's activity in Agri-tech research is broadly in line with the UK average. The institutions that dominated the UK-funded projects were similarly prevalent in EU-funded projects, alongside the notable addition on TWI Limited.

Methodological note on the use and meaning of Location Quotients

D.13 Throughout the SIA process we have been asked as providers of data and analysis to provide not only raw figures, but also some help in making sense of them. If the data sources allow, we do this through metrics and indicators that are normalised or referenced to different baselines or comparators. This can help the readers of the figures to make comparisons or to figure out if a particular data point is high or low with regards to a particular baseline.

D.14 For this, we usually provide the shares of particular metrics with respect to the national averages. For some data sources where we work thematically in addition to geographically, we try to go a bit beyond and provide another metric called the Location Quotient (LQ). We use the LQs to try and abstract as much as possible the size of the object of analysis (in this case an SIA partnership region) and to give some indication on whether an activity (be it research and innovation funding, employment, patent output, etc.) is above or below an expected baseline/threshold.

D.15 Location quotients have been used in the past by the ONS and the ERC in the Witty review and the previous UK Industrial Strategy, using data of employment and number of companies, in order to work out areas of industrial and jobs concentration throughout the UK. It can be a bit tricky to unpack what the LQ conveys, because it is sometimes referred as a "concentration/specialisation" metric while in other occasions it is referred as "position over or under, relative to a baseline". These two explanations are compatible and come from the fact that you can write the formula for calculating the LQ in two (equivalent) ways (see formula below).

$$LQ = \frac{\frac{region_{theme}}{region_{all}}}{\frac{country_{theme}}{country_{all}}} = \frac{\frac{region_{theme}}{country_{theme}}}{\frac{region_{all}}{country_{all}}}$$

D.16 From the ERC's own paper Localisation of Industrial Activity across England's LEPs (which underpinned the LQs used in the Witty review): "Location Quotients are used to provide a broad illustration of the extent to which a particular activity is over- or under-represented [in a particular region] relative to the national average." [...] "If the LQ for an activity is less than

1, the [region] has a smaller share of [activity] than the GB average; if the LQ for an activity is greater than 1, the [region] has a larger share of [activity] than the GB average."

D.17 At the same time, other definitions emphasise the "agglomeration" aspect. From NESTA's Creative Clusters and Innovation report: "Location quotients are a standard metric of agglomeration in economic geography that measure a given area's degree of specialisation in a sector, compared with the national average. A location quotient larger than 1 indicates that a particular sector is more important to the local economy than it is to the British economy."

Annex E: Top 100 agri-tech companies in the East of England

E.1 This paper was produced by Technopolis as part of the technical support role to the SIA. It provides a high level overview of the scale and nature of agri-tech firms based in the East of England SIA area. It focuses on relevant businesses that have a registered office or trading address within the East of England.

Methodology

E.2 The analysis draws on Bureau van Dijk's FAME database. This contains information on all businesses with a UK base as held by Companies House. FAME also provides descriptions of each company's activities, ownership structure, and the Standard Industrial Classification (SIC) code that each firm says best summarises its business activity.

E.3 Using FAME, we have compiled a list of firms that a) has a registered office or trading address within the East of England, and b) falls within the two agri-tech SIC code definitions below:

Table E-1: Agri-tech SIC codes used in our analysis

Broad agri-tech definition	Narrow agri-tech definition
0164: Seed processing for propagation 10: Manufacture of food products 11: Manufacture of beverages 2015: Manufacture of fertilisers and nitrogen compounds 202: Manufacture of pesticides and other agrochemical products 2651: Manufacture of instruments and appliances for measuring, testing and navigation 283: Manufacture of agricultural and forestry machinery 74909: Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying) 2222: Manufacture of plastic packing goods 8292: Packaging activities 712: Technical testing and analysis 7219: Other research and experimental development on natural sciences and engineering	0164: Seed processing for propagation 2015: Manufacture of fertilisers and nitrogen compounds 202: Manufacture of pesticides and other agrochemical products 2651: Manufacture of instruments and appliances for measuring, testing and navigation 283: Manufacture of agricultural and forestry machinery 74909: Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying) 2222: Manufacture of plastic packing goods 8292: Packaging activities 712: Technical testing and analysis 7219: Other research and experimental development on natural sciences and engineering

Midlands Engine SIA

Analysis of firms – broad definition

E.4 We have enclosed a spreadsheet that shows the top 100 agri-tech firms (by global turnover) that are present in the East of England. It should be noted that as far as possible, the list excludes multiple subsidiaries of the same firm to help understand the full range of firms operating within the SIA area. As such, the turnover figures we report may be lower than the actual turnover for each parent company.

E.5 The list reveals several points:

- These 100 firms provide a global turnover worth approximately £2.8 billion. This is in fact larger than the total global turnover generated[1] by all agri-tech firms with a presence in the East of England (reflecting the fact that some firms generated negative turnover).
- Several major names feature on this list including Britvic, Greene King, Hotel Chocolat and Branston. Nevertheless, SMEs (i.e. those with fewer than 250 employees) are particularly prevalent in this list, accounting for two thirds of the companies listed.
- Of the 100 firms, 71 provided information on where their global ultimate owner (GUO) was based. Some 45 are UK-owned businesses although the East of England is also home to some foreign-owned companies too, including from Germany (e.g. Eppendorf Cyrotech), the US (e.g. PPD Global) and Japan (Apical Limited).
- Table E-2 below breaks down these agri-tech firms by SIC code. As shown, two categories, 'Manufacture of food products' and 'Other professional scientific and technical activities' account for over half (52%) of the firms on our list. Additionally, all of the SIC codes that form part of our broad agri-tech definition are represented with the exception of 'seed processing for propagation.'

Table E-2: Breakdown of broad definition agri-tech firm by SIC code

SIC code	Number of businesses
10: Manufacture of food products	31
11: Manufacture of beverages	5
2015: Manufacture of fertilisers and nitrogen compounds	2
202: Manufacture of pesticides and other agrochemical products	1
2222: Manufacture of plastic packing goods	5
2651: Manufacture of instruments and appliances for measuring, testing and navigation	10
283: Manufacture of agricultural and forestry machinery	3
712: Technical testing and analysis	3
7219: Other research and experimental development on natural sciences and engineering	15
74909: Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)	21
8292: Packaging activities	4
Total	100

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E.6 Table E-3 below shows the registered trading address for each of the 100 firms. Although Cambridge is the most frequently cited location, the table shows that the companies are spread across the full SIA area from Lowestoft to the east, Loughborough to the north and west, and Hertford to the south. There is certainly little evidence of geographical clustering of firms within the East of England area.

Table E-3: Registered trading address of East of England-based agri-tech firms (broad definition)

Location	Number of companies	Location	Number of companies
Cambridge	12	Derby	2
Lincoln	6*	St Albans	2
Hemel Hempstead	4	Borehamwood	2
Loughborough	3	Boston	2
Leicester	3*	Maldon	2
King's Lynn	3	Ipswich	2
Ely	3	Welwyn Garden City	1
Bury St Edmunds	3	Spalding	1
Norwich	3	Harpenden	1
Coalville	3	Melton Constable	1
Huntingdon	3	Lowestoft	1
Hertford	3	Eye	1
Stevenage	2	Cromer	1
Royston	2	Newark	1
Great Yarmouth	2	Southend-On-Sea	1
Watford	2	Newmarket	1
Sleaford	2	Harwich	1
Chelmsford	2	Gainsborough	1
Melton Mowbray	2	Lutterworth	1
Brentwood	2	Basildon	1
Peterborough	2	Woodbridge	1
Colchester	2	Grantham	1
Saffron Walden	2	Berkhamsted	1

*Technopolis analysis of FAME database. * denotes areas falling just outside the SIA area boundary*

Analysis of firms – narrow definition

E.7 The enclosed spreadsheet also provides a list of the top 100 agri-tech firms (again, by global turnover) according to our narrow sectoral definition. Once more, the list excludes as far as possible multiple subsidiaries of the same parent company. The list shows the following:

- The 100 firms provide a global turnover worth approximately £689 million in comparison to an East of England total of £358 million. Again, this reflects the fact that some firms in our narrow agri-tech definition generated negative turnover during the last year for which data were available.

- The overwhelming majority of companies on the list (83%) are SMEs and therefore have less than 250 employees worldwide. The larger scale companies include the biotechnology firm, MedImmune (based in Cambridge); the printed film manufacturer, Coveris (located in Spalding); and the pharmaceutical design company, Bespak (located in Hemel Hempstead).

- Of the firms featured on the list, 89 provided details on their global ultimate owner. Some 43 firms are UK-owned although internationally owned agri-tech firms also have some presence in the East of England. For instance, 11 companies have American owners (including Cambridge-based PPD Global and Huntingdon-based Envigo) while Ireland, Germany and France-based firms are also represented.

- Table E-4 below shows the SIC code classification of the 100 firms. Two activity areas are particularly prevalent with 'Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)' and 'Other research and experimental development on natural sciences and engineering' accounting for over half (58) of the firms' activities. Once more, 'seed processing for propagation' is the only activity area in our agri-tech definition that is not represented.

Table E-4: Breakdown of narrow definition agri-tech firm by SIC code

SIC code	Number of businesses
2015: Manufacture of fertilisers and nitrogen compounds	5
202: Manufacture of pesticides and other agrochemical products	1
2222: Manufacture of plastic packing goods	6
2651: Manufacture of instruments and appliances for measuring, testing and navigation	16
283: Manufacture of agricultural and forestry machinery	5
712: Technical testing and analysis	4
7219: Other research and experimental development on natural sciences and engineering	25
74909: Other professional, scientific and technical activities (not including environmental consultancy or quantity surveying)	33
8292: Packaging activities	5
Total	100

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E.8 As with our broad agri-tech definition, table xxx shows that even using a narrow sectoral definition, companies are dispersed across the East of England region. There is a slightly higher concentration of Cambridge-based companies (18 firms in contrast to 12 under the broad definition) but nevertheless, there is little evidence of a clustering of companies in any one part of the SIA area.

Table E-5: Registered trading address of East of England-based agri-tech firms (narrow definition)

Location	Number of companies	Location	Number of companies
Cambridge	18	Leicester	2
Lincoln	4	Sleaford	1
Royston	4	Hatfield	1
Loughborough	3	Berkhamsted	1
St Albans	3	Wisbech	1
Coalville	3	Colchester	1
Ely	3	Chatteris	1
Huntingdon	3	Spalding	1
Southend-On-Sea	2	Borehamwood	1
Norwich	2	Bishop's Stortford	1
Lutterworth	2	Great Yarmouth	1
Chelmsford	2	Haverhill	1
Bury St Edmunds	2	Loughton	1
Derby	2	Cromer	1
Watford	2	Lowestoft	1
Hemel Hempstead	2	Hitchin	1
Maldon	2	Halesworth	1
Hertford	2	Basildon	1
Peterborough	2	Harpenden	1
Ashby-De-La-Zouch	2	Tring	1
Saffron Walden	2	Melton Mowbray	1
Ipswich	2	Gainsborough	1
Stevenage	2	Newmarket	1
King's Lynn	2	Letchworth	1
Brentwood	2		

*Technopolis analysis of FAME database. * denotes areas falling just outside the SIA area boundary*