

<b>Institution: Harper Adams University</b>
<b>Unit of Assessment: UoA6</b>

**1. Unit context and structure, research and impact strategy****Context and structure**

As a specialist institution submitting to a single unit of assessment, Harper Adams University (HAU) is not submitting a REF 5a. As such, this introductory section contains more general information about the University for context.

HAU is a specialist institution, comprising 160 FTE academic staff and c. 3000 students, focusing on the rural economy and industries reliant upon that economy, with a specific commitment to sustainable agriculture and land use. HAU's mission is to provide; **World leading higher education and research for the delivery of sustainable food chains and the protection of rural resources for future generations.** This submission is based on the research of a collaborative group of 45 staff (42.35 FTE) from across the five academic departments of the University. This represents an increase from 17.4 FTE in 2014, demonstrating our commitment to growing research and impact activity. Research income per annum has grown by 35% over the assessment period from £2.34m to £3.17m (in the last pre-Covid year). Research postgraduate student numbers have increased from 56 in 2012/13 to the current number of 97 and research outputs (peer reviewed papers) across the University have grown from 49 per annum in 2013 to 115 per annum in 2020.

Research activity at HAU is organised into either multidisciplinary research centres or research groups defined within a theme, and delivers international research and impact in a number of areas including in policy and practice. Our research has a clear focus on agriculture, livestock systems designed to help reduce emissions to the environment, and new approaches to the management of soils, forests, water resources and biodiversity. All research is supportive of practitioners and advisers to move towards sustainability of food production systems. We are developing research interests in artificial intelligence to help automate processes and improve agricultural, environmental or veterinary analyses and decision-making, and engaging with rural businesses and agri-food supply chains who will need expertise in data management and analysis.

The strategic focus of the University is to provide a vibrant, sustainable environment for research and research-led teaching to maintain our status as the premier specialist provider for sustainable agriculture and land use. The tangible outputs of this approach, and our place within the HE sector can be measured by the many awards won by our students and the University. The University has in recent years won various THE Awards relating to research collaborations: Outstanding Business/University Collaboration; Technological Innovation of the Year; and Outstanding Estates Strategy (based on environmental sustainability). In addition, we have been nominated for University of the Year; and the THE Leadership and Management Award (THELMA) for International Strategy. There is recognition globally of the reputation we have established with the industries in the sectors we serve as shown in the QS World University Subject Rankings 2018-2020 for Employer Reputation, where HAU ranked second in the world. This clearly demonstrates the way in which the University works with industry, at home and overseas, to positive effect including joint research projects, student industry placements and knowledge exchange activities. Since REF 2014 we have forged important new relationships with universities, institutes and businesses across five continents.

Research at HAU is managed by the Deputy Vice-Chancellor (Mills until November 2020, thereafter Lee), supported by a Director of Research (Kettlewell 2010-2018 and thereafter Arnold). Research is frequently delivered through interdisciplinary centres (e.g. Global Institute of Agri-Tech Economics, Agricultural Centre for Sustainable Energy Systems, Centre for Evidence Based Agriculture, and the Fresh Produce Research Centre) or, where appropriate, research groups defined within themes where a critical mass of research occurs (e.g. areas such as animal nutrition, welfare and behaviour, and food innovation). Centres have Directors (e.g. Behrendt, Theodorou, Leather, Randall and Monaghan) and within centres, areas of activity have an identified lead scientist to coordinate activities and ensure strategic delivery. The University has an integrated approach to research across the entire agri-food supply chain and is presenting a

single group of staff with a significant responsibility for research to REF, within an overall theme of **'Sustainable Agriculture'**.

The University Research and Knowledge Exchange Committee develops policy and strategy which is subsequently approved by Academic Board. 'Research' is a standing item on the agenda of monthly University and Departmental staff meetings. The University Research Office explores research opportunities from all sources and provides staff with weekly updates of opportunities and a weekly blog for background information. The Research Office and Finance Department provide support for grant applications, contracts and IP negotiations, further supported by three Business Development Officers within the University. HAU's vision is that we engage with the industries, professions, organisations and policy-advisors that comprise and influence the global agri-food chain which in-turn supports the UK rural economy, to deliver an outstanding, practice-based research and learning environment. The University makes positive contributions to the UK rural sector, the wider economy and society by securing the skills needed by our industries and professions. Our research and research-led teaching helps inform stakeholders views regarding food, animal wellbeing and the environment, contributing to UK economic prosperity and developing new and emerging technologies.

In 2020, in collaboration with Keele University, HAU established the 9<sup>th</sup> Veterinary School in the UK. This has involved a >£10m capital investment in facilities by the University which is a substantial investment for a small specialist institution. Our strategy is based on the integration of veterinary science education and research with our existing strengths in animal sciences, agriculture, agricultural business management and, uniquely, with our expertise in agricultural engineering/agri-technology we believe that HAU could be a critical deliverer of future interdisciplinary advances. We have worked successfully with academic and industry partners to bring about a number of initiatives since 2014, including the Saputo UK Innovation Centre, the Midlands Hub of the Agri-EPI Centre for Agricultural Engineering and Precision Innovation and the forthcoming Newport Innovation Park scheme, in which we are supporting our Local Authority, LEP and the DTI in agri-tech economic development.

Our sandwich degrees are a major factor in student preparation for the world of work, but also in putting research-led education into practice. Each student undertakes a 1-year placement which includes a research project of relevance to the placement provider, enabling us to remain in close contact with over 500 employers world-wide.

We have continued to highlight the importance of rural concerns, and our subject base, to our regulatory and funding bodies and to Government and have contributed to the development of the national agri-technology agenda with world-first extension work e.g. our Innovate-UK funded Hands-Free Hectare/Hands-Free Farm programmes.

With the passing in to law of the Agriculture Bill (November 11<sup>th</sup>, 2020) the University's research will support the transition required for the sector in a post-Brexit environment, noting that the Bill could have wider implications for the shape of the agri-food sector in future. Research innovations across the agri-food supply chain drive improvements in productivity, reduce emissions and costs and contribute to global food security. A steady increase in research funding over the last decade, creation of research facilities coupled with the support provided by industrial and public sector funding sources, and appointment of research active staff in recent years has transformed the contribution that HAU is making to the global challenges of sustainable agriculture and future land use.

The University helps develop innovative approaches for the provision of high-quality food, whilst at the same time minimising the impact of food production on the environment, at a time when there is considerable structural change, perturbations to geopolitical groupings and growing volatility in global food systems. The University's expertise in agri-food production systems across the agri-food chain, agricultural engineering, animal health and welfare, environmental management and bioenergy production provide a resource that is addressing some of the most critical challenges faced by the international community over the next few decades. By continuing

to conduct research that supports industry, and training future generations of applied scientists who will work within the agri-food chain and help manage our rural resources, HAU will play a distinctive and important role in underpinning the UK's response to achieving carbon Net-Zero within the agricultural and land use sectors, achieving sustainable global food security and delivering to the UK's Paris Climate Agreement commitments.

### Research and impact strategy

The University's *Strategic Plan* contains a key vision to be '*A recognised centre of research excellence, especially in the application of science and technological advances*'.

Our portfolio of research has been expanded over the last planning period with important new relationships with universities and businesses across 5 continents.

The University is mindful that the next five years will see a significant period of change following the UK's departure from the EU. This will result in disruption for the core disciplines of agriculture, food, rural land, environmental management, engineering and veterinary science in which we specialise. Whilst this might pose a number of risks, we are confident that it will also signal new opportunities for research to work with, and support, related industries and professions as they seek to adjust to their new operating conditions. It also seems likely that if the UK is to prosper beyond its membership of the EU, it will have to forge new ways of interacting with a wider range of countries. UK expertise in our subject base will be critical in contributing to these interactions, not least in new technologies and techniques where already, other countries wish to emulate the University's pioneering work in agri-technologies. The University will be open to opportunities to operate in new environments, but also ensure that we maintain strong relationships with target markets for joint research activities. HAU is already seeing success in leading bids associated with the challenges imposed on the agricultural sector following leaving the EU through leading a project on Agricultural Trade negotiations funded by AHDB.

Our strategic plan states that in fields where subject specialists are in short supply, we must seek to develop our own talent to continue to have academic experts who are also able to draw from their experience of the world beyond higher education. This will be a significant challenge for the University, but as a specialist institution delivering applied research and practical and theoretical education, it will be an essential aim for the University over the lifetime of our plan.

The UK has to address two aspects of delivery that have been given scant attention in the last 20 years, and which feature in our strategy. These are a need for applied research and development together with the translation into practice of innovations in basic science and technology; and the need to secure new research-informed entrants at all levels to the land, food and farming sectors and to the rural economy more generally. In seeking to establish HAU as a critical part of the 'supply line' for these requirements we have strengthened our position as a contributor to the health of the UK agri-food chain, as well as ensuring that our research will help the UK agri-food system make a substantive contribution to addressing the challenge of providing healthy food to a growing global population that also protects the environment. Importantly, this includes a focus on closely related subject areas in animal nutrition, health and welfare, and agricultural engineering. In addition, we have extended our role in renewable energy production as another key feature of our sustainable agriculture and land use research activities. We anticipate greater attention to be directed at renewing the higher-level skills of those working in industry over the planning period, underpinned by our near market research. In addition, we play a key role in acting as an independent and authoritative source of advice and comment on issues of concern to the agri-food supply chain and to the wider rural economy. This is evidenced by contributions to Government bodies and committees, for example Hare was a member of the UK Expert Committee on Pesticides 2015, an expert scientific committee that provided advice on pesticide approvals and authorisations to the HSE and government ministers. We measure success in terms of research income and outputs, the level of our engagement with industry (c. 500 businesses), the citations of our published research, and in periodic independent assessments by key stakeholders of the profile and contribution of the University.

**Investing in Impact.** Our impact strategy sets out that we will establish a top 10 position amongst UK agri-food institutions for impact and communication of our research, so as to underpin our engagement with industry, and our capacity for informative and useful education and research. We continue to develop the role and reputation of HAU as a contributor to national policy formulation and delivery on enhancing rural economic development and the UK's contribution to global food security. HAU provides key inputs into strategic decision making at LEP and local authority levels and has been central to a decision to create a business park based on agri-tech in the local area. The University seeks active engagement with local businesses and provides support, in particular to SMEs, in terms of provision of facilities, technical advice including innovation and product development and high-level skills. Internationally, we work with the academic community, collaborative institutions across the world and the DIT to attract industry contacts to the UK to build on the specialist research skills here. Nationally, we have created relationships with UK Government to directly support industry. Regional impact is clearly defined in our local growth and regeneration statements, through a variety of projects in which we have partnered or invested.

**Objectives over the REF assessment period since 2014 have included:**

- *Deliver Research Outputs:* Work with academic staff to plan, support and deliver research outputs across our subject base that will maximise the impact of our research activities whilst achieving high quality ratings.
- *Industry Engagement with Research:* Construct and deliver a coordinated programme of industry engagement with our research activities to ensure that our research has greater influence within industry over the planning period and that, where relevant, the benefits of mutual proximity are exploited.
- *Strengthen Research Capacity:* Take opportunities to strengthen our research expertise in key areas of our portfolio, and to enhance our provision in the social sciences to better support the translation of agri-food science and engineering-led research into practice.
- *Postgraduate Research Numbers:* Grow our postgraduate research student numbers to 80 over the planning period, in part as a means to secure future academic talent for the University.
- *Research Informed Curriculum:* Pursue the development of a balanced portfolio of education and research that will enable the University to benefit from research informed teaching across the curriculum whilst maximising the impact of our performance in national research assessments.
- *Public Understanding:* Promote a better understanding of our research activities and performance with public research funding bodies and the consumer.
- *New Collaborations:* Seek new collaborations with other UK and international universities to mutually enhance our capacity to generate research income and high-quality research outputs.
- *Applied Research:* Continue our focus on applied research to exploit this currently under-developed element of the research spectrum within the agri-food sector.

**Progress with objectives**

*Deliver Research Outputs:* It is important to note that the University is not focussed solely on REF-aligned outputs but strives to achieve a balance to meet the needs of a wide range of stakeholders. As such, a proportion of our outputs are aimed at multiple industry-facing end-users through trade journals, industry bodies and events (e.g. the Soil and Water Management Centre training days) and knowledge exchange activities across the world (e.g. our Hands-Free Hectare/Farm KE activity which has been publicised in 86 countries). Notwithstanding, planning meetings were held with staff with a significant responsibility for research throughout the assessment period to ensure clear understanding of REF requirements and adherence to strategic objectives. This strategy has resulted in a significant increase in the number of peer reviewed open access publications.

*Industry Engagement with Research:* The University has significantly increased our interaction with industry partners during this assessment period. In particular, emphasis has been placed on



the Department of Business Energy and Industrial Strategy funding with significant success achieved through the Government's Agri-tech Strategy for capital (>£7m) involving >100 industry partners, and, notably, funding from Innovate UK (27 projects, totalling over £4.5million, and working with 92 collaborators nationally and globally). Horizon 2020 has also facilitated greater industrial partnerships and European Regional Development Funding has enabled the University to work with >90 companies to develop their innovative capacity within the Agri-Food sector.

*Strengthen Research Capacity:* Approximately 40% of submitted staff have been recruited since 2013. This targeted recruitment, and promotions, has greatly increased our capacity to deliver high quality research and impact. The assessment period has seen significant growth in total academic staff numbers (16.7%) and in some cases has facilitated the creation, or strengthening, of research centres/thematic groups (e.g. Theodorou and Kirby - Agricultural Centre for Sustainable Energy Systems; Lowenberg-DeBoer, Harris, Huang and Behrendt - Global Institute for Agri-Tech Economics; Vickers and Beacham - Urban Farming Group; Arnold, Segar, Roberts and Campbell - Centre for Integrated Pest Management; Beaver, Charlton, Shaw, Davies and Herath - Animal Production Science Centre; Hartley, Jeffery and Crockford - Soil and Water Management Centre). The University has been able to attract world-leading expertise in some of our discipline areas (Arnold, molecular plant pathology; Lowenberg-DeBoer and Behrendt, agricultural economics; Theodorou, sustainable energy; Davies aquaculture).

*Postgraduate Research Numbers:* Since 2012/13, we have had a total of 771 research student registrations and the number of research students has increased considerably, from a total of 56 in 2012/13 to the current number of 97 (PhD & MRes).

*Public Understanding:* An initiative to enhance worldwide public understanding of some of the issues facing 21st Century agriculture based on our research outputs was launched at HAU in 2019/2020 with support from the Garfield Weston Foundation. A unique position of Chair of Public Engagement in Agriculture was to have been created in early 2020 but has been delayed by the pandemic.

The largest citizen-focussed community events, delivered at HAU in 2018 and 2019, were our Field to Fork Festivals celebrating the journey of food, based in part on our research outputs. Staff, students and sponsors delivered knowledge exchange activities for a schools' day for over 800 pupils and a public day to encourage the community to engage and gain a better understanding of the technologies used in food production and environmental management. More than 18,000 members of the public of all ages attended. HAU is a major contributor of practical information for the Food and Farming Futures repository, a national initiative aimed at the food and farming sector.

In 2018 we joined CWIN, a Capgemini World Innovation online and in person event, where staff from HAU demonstrated Agriculture 4.0 and the new farming revolution by looking at artificial intelligence, using big data, and the technologies applied within the Hands-Free Hectare programme.

*New Collaborations:* The University has established 29 new collaboration agreements with international HEIs and has also established a wide network of University partners within the UK (for details see Partnerships section below).

*Applied Research:* The University prides itself on the quality of research outputs from fundamental science (e.g. anaerobic gut fungi published by Theodorou in Science; soil international policy published by Jeffery in Nature; methodology for making informed ecological choices by Randall in Nature), through strategic research (e.g. global food safety by Nayak in Trends in Food Science and Technology; reorganisation of butterfly communities in extreme weather events by Leather in Ecography) to applied research. Much of our agenda is driven by the needs of the industries we serve. A few examples of applied research include microchip slug tracking to facilitate precision application of control measures (Pope); drought tolerance in crops to adapt to climate change (Kettlewell); lettuce post-harvest discolouration to improve shelf life (Pink, Monaghan and Beacham); understanding dairy cow behaviour to improve milk yields (Rutter, Beaver and

Charlton); nutrition optimisation to improve poultry (Pirgozliev) and dairy cow (Sinclair) yields; and reduced soil compaction to improve crop yields (Misiewicz).

*Research Informed Curriculum:* A comprehensive revision of the entire University undergraduate portfolio was undertaken in 2017. This ensured that research strengths were translated into revisions across the undergraduate portfolio. At level 7, many new awards have been established since 2013 based on the research strengths including MSc in entomology, plant pathology, data science, agroecology, ruminant nutrition, agricultural sciences and integrated pest management. In addition, a new portfolio of MRes awards has been established, resulting in an increase in research student registrations since 2013 (0 in 2013 to 21 students in 2020).

### Strategy 2020-2025

The University will continue to enhance its research capacity and capability. The University's strategic aim for the next five years will focus on helping to achieve '**Net Zero**' in agriculture and food supply chains within the context of co-delivering the wider requirements of sustainable agriculture (e.g. rural economies, animal welfare and Nitrogen/Phosphorus pollution). In recent years we have focussed on building a research base of academics able to address the key issues of carbon reduction within agriculture and the environment, whilst recognising the constraints of a single metric approach, i.e. carbon, in defining a sustainable system. We will continue to collaborate with leading partners in academia (within the UK and worldwide) and those in industry to expand our research and increase its impact in defining policy and sustainable practices across the supply chain.

UK agriculture is currently responsible for 45.6m tonnes of CO<sub>2</sub> equivalents (eq) per annum equating to circa 10% of total UK emissions. The Committee on Climate Change has recommended a 64% reduction in greenhouse gas emissions from *the agriculture and land-use sector* to meet a 2050 net zero carbon target in the UK. To achieve this will require application of a range of mitigation and carbon removal strategies. For all agricultural emissions, a recent assessment of cost-effective mitigation strategies available concluded there is the potential to reduce emissions by 7.1 Mt CO<sub>2</sub>-eq by 2035. This is only 19% of the goal for total agricultural emissions, leaving 81% to be delivered between 2035 and 2050, emphasising the needs for concerted action and research.

To maximise speed of uptake and rate of change requires coordinated and collaborative work within and across sectors, between farmers, food processors and their supply chain partners, and partnerships between government, scientists and consumers. HAU is perfectly positioned to drive this required change due to its strong reputation for working across the supply chain. Our expertise, facilities and research deliver across primary production to food innovation, with critically important disciplines including agricultural engineering, precision agriculture, food science and one health. We have identified eight focus areas to deliver our strategy. Progress in these areas will be achieved through a multidisciplinary approach involving natural and social scientists, and engineers.

Our eight focus areas are:

1. *Smart (Agriculture 4.0), Precision and Urban Farming:* Agriculture will continue to need to produce more products from fewer inputs. The University has strengthened its research capacity for optimising agricultural inputs and is building a research capability that will focus on precision farming through the use of automation, robotics (including swarm robotics) and extending the use of drone applications. This expertise, driving the advancement of precision farming, will be further extended to solving some of the challenges of urban farming as many of the constraints around resource use are the same.
2. *Soil Health:* Notwithstanding soil being a carbon capture approach, improving soil carbon storage will improve overall soil health (biological functioning) through improved physical structure and microbial aerobic processes, i.e. more nutrients in the soil will be assimilated

into biomass (plants, animals and microbes) rather than dissimilated into pollutants (e.g. nitrous oxide), allowing it to be more productive with lower inorganic inputs. Therefore, increasing soil organic carbon will contribute to net zero carbon targets either directly (carbon capture) or indirectly (soil health). Our focus will be on soil compaction (responsible for >90% of energy requirements each year during cultivation) and soil ecosystem functioning.

3. *Land Use*: Mitigation alone will not achieve net zero. Carbon sequestration by the natural landscape and other approaches to removal of greenhouse gases from the atmosphere can contribute significantly to balancing emissions from agriculture. How carbon is accounted for will need to realise the potential of certain land-types for carbon sequestration. Moreover, these land-based benefits need to be credited to the agricultural sector (e.g. hedgerows on farm and land set-aside for forestry). Land use, including improvement of soil health, will play a critical role in contributing to this but uncertainties remain about the relative contributions of land management, where land remains broadly constant, as opposed to land use change where a new land use such as forestry is introduced. Through the Centre for Evidence-based Agriculture we will make use of systematic review/mapping methodologies to identify new management processes in agroecosystems to optimise land use for efficiency and, ultimately, carbon emissions.
4. *Ruminant Livestock*: A greater understanding of rumen microbial ecology may offer solutions to lower methane through microbial manipulation and reducing methane producing archaea (e.g. through gut microbial programming or dietary supplements). Use of home-grown sources (especially protein) will reduce reliance on imported soya and the impacts associated with deforestation. Use of co-/by-products in livestock feeds, especially those not contributing to the competition between food and feed will significantly reduce impacts. Through our work on animal health and welfare, in particular the integration of sensor data for early warning of animal health issues, will further contribute to reducing methane production from livestock production through healthier more productive animals.
5. *Energy Production and the Circular Economy*: Our world leading position with anaerobic gut fungi biology and micro-anaerobic digestion technologies will help drive the development of low or zero carbon emission energy systems. We aim to create a circular nutrients system for agriculture which works across economic, social and ecosystem dimensions, where waste loops are closed, surpluses shared and multiple forms of value retained and circulated.
6. *Integrated Pest and Disease Management*: We have established a critical mass of pest and disease expertise who will focus on the reduction of losses to crops caused by pests, pathogens and weeds, both in the field and post-harvest, that will reduce the amount of food we need to grow through integration of precision technologies and reducing resource intensive and costly chemical interventions.
7. *Public Engagement*: The University is committed to creating a Chair of Public Engagement in Agriculture to ensure new technologies and processes required for the 21<sup>st</sup> century agri-food supply chains are understood by a wide range of stakeholders.
8. *Research Students*: A core aim will be to continue the growth of our population of research students. This will be achieved in the short term through our partnership in the Midlands Integrative Biology Training Partnership (MIBTP), but longer term through participation in other successful DTP bids and industrial sponsored research students delivered through industry embedded within our campus (e.g. Saputo, Agri-Epi Innovation Centre, ABP Food Group).



**Research Centres and Thematic Groups**

To facilitate delivery of our research strategy, research at HAU is organised into either multidisciplinary research centres or thematic research groups. A selection of these are described below.

**Soil and Water Management Centre** (Jeffery, Crockford, Misiewicz, Back, Hartley)

An industry-led initiative to help UK farming make the most of its two most precious assets.

- Acting as a central source of soil and water management information and expertise, and a national forum for establishing essential improvement priorities.
- Making practical soil and water management training and advisory materials widely accessible and co-ordinating farm-based workshops and demonstration projects.
- Instigating and supporting applied soil and water management research addressing particular challenges and improvement opportunities.

**Centre for Integrated Pest Management** (Leather, Pope, Segar, Campbell, Hare, Arnold, Edwards, Roberts, Back)

A multidisciplinary team addressing UK and global issues in agricultural, forestry and horticultural crop production.

- Research interests in entomology, chemical ecology, pest monitoring, application technology, nematology, pesticides, plant pathology and weed science.
- Expertise in UK and tropical forestry, arable crops, horticultural crops, field vegetables, soft fruit and protected crops.

**Fresh Produce Research** (Monaghan, Vickers, Beacham, Hare)

A multidisciplinary team addressing UK and global issues in horticultural crop production along the supply chain.

- Research on crop breeding, crop production, post-harvest physiology and food safety.
- Expertise in field vegetables, soft fruit and protected vegetables.

**The Centre for Evidence-Based Agriculture** (Randall, Herath, Huang)

The Centre aims to 'synthesise' existing agri-food evidence to support decision-making in policy, industry, practice and research.

- Development of structured 'evidence synthesis' methods used to collate and evaluate existing research to support decisions.
- Evidence syntheses for policy formulation within Defra and European Food Safety Authority.
- The Centre has formed a partnership with the Universities of Bangor and Exeter to create the UK Centre for Collaboration for Environmental Evidence (CEE). The CEE is a global network that also has centres in Australia, Canada, France, South Africa and Sweden.

**The Global Institute for Agri-Tech Economics** (Behrendt, Lowenberg-DeBoer, Huang, Peets)

A unique worldwide network of leading multidisciplinary researchers and stakeholders bringing together experts working on the application, adaptation and adoption of innovative agricultural technologies. The Institute is committed to developing and implementing:

- Economic analyses to inform decision making at the private and public policy levels through applied research and international collaboration.
- A multidisciplinary team approach to identifying challenges and addressing the gaps between technology development and decision making in uncertain environments.
- Data analytics to aid real-time decision making in value chains and policy.

- A mechanism for the exchange of ideas, feedback on research results and for jointly promoting high level interdisciplinary research into Agri-Tech Economics.
- Increased engagement with the global farming community, industry and government stakeholders.

**Urban Farming Group;** (Vickers, Monaghan, Beacham, Harris, Kirby)

A multi-disciplinary team focussed on the challenges of commercial food production in urban environments. Relevant research funded through industry and government, has investigated:

- Barriers for implementation.
- How widely-available LED lighting is radically reducing the energy cost of indoor growing.
- Optimisation of fruit production using advanced technologies such as hydroponics, vertical farming and climate control.
- Integration of renewable energy sources into urban farming businesses.
- The creation of city circular economies that feed into urban farming systems.
- Legal and social constraints and opportunities, with the view to helping policy makers design resilient cities.

**2. People****Staffing strategy and staff development**

**Staff profile:** Staff with significant responsibility for research comprise a head count of 45, of which 15 (33%) are female. The group consists of 10 (c.22%) Lecturers, 13 (29%) Senior Lecturers, 9 (c.20%) Readers/Principal Lecturers, 13 (c. 29%) Professors, and 9 (20%) are within 4 years of the start of their research careers. This balance across five levels of staff ensures that the University is actively succession planning. Proactive mentoring, training and promotion rounds are used, in part to ensure that the University maintains an appropriate range of skills and disciplines and delivers to staff CPD. The University maintains an increasingly rare portfolio of whole organism skills amongst its research active staff in both animal and crop sciences.

Research active staff are ably supported by a highly qualified and skilled group of technical support staff including: 9 laboratory staff, 21 animal technical support staff, 6 support staff in the Crop and Environment Research Centre and 11 farm staff. Each of the 5 academic departments has an administrator whose responsibilities include supporting research activity. The University operates a Research Office with a Director of Research and two members of staff who support academics in the preparation of grant proposals, contract management, IP issues and business engagement. The Finance Department has dedicated business partners to advise and assist with proposal costing preparation and are responsible for invoicing funders. The University also provides access to a Knowledge Exchange Coordinator who actively supports academics by connecting them to a wide range of stakeholders (including industry and sectors of the public) and, over the REF assessment period, a Technical Author who re-purposes complex technical information from our research portfolio to enable improved accessibility for other audiences. Short research notes (around 20 per annum) are produced to provide explanatory summaries of our current and completed research projects, aimed at non-specialists, students and practitioners in farming and associated industries.

Academics are also supported by three Business Development Officers who frequently adopt a leading role in linking academics with industry partners, especially when applying for Innovate UK funding.

**Recruitment:** Over this assessment period, the University has had a strategic objective to increase the quantity and quality of research in specific areas of its research programme. The University has focused on the recruitment of research active staff with appropriate expertise which, in part, has resulted in the increase from 17.4 FTEs at REF 2014 to 42.35 FTEs for REF 2021. Academic staff numbers have increased from 137 in 2014 to 160 in 2020 (16.7%) exemplifying the dynamic environment experienced over the assessment period. Newly appointed staff are placed into the most appropriate academic department and are encouraged and supported to join at least one of the University's research centres or thematic research groups based on their research interests. Targeted areas for development to meet University strategic aims have involved a collective effort by academic staff to secure external funding. An example of this is creation of two Professorial positions (Behrendt and Lowenberg-DeBoer) in Agri-Tech Economics, globally unique at the time of appointment, with £0.5m funding secured from the Elizabeth Creak Charitable Trust. One appointee joined HAU from Purdue University in the USA and one from Charles Sturt University, Australia. This has enabled the University to establish a global network in agri-tech economics. Other strategically focused recruitment has included soil microbial ecology, sustainable energy, urban farming, data analytics, physical chemistry of foods and parasitology, all of which address our current and future research agenda. There has also been substantial capacity building around existing research strengths such as entomology, animal behaviour and molecular plant pathology.

**Staff development:** The University has adopted the principles of the Concordat to Support the Career Development of Researchers, and ensure that researchers are equipped and supported to be adaptable and flexible in an increasingly diverse global research environment and employment market. The University provides opportunities, structured support, encouragement

and time for researchers to engage in professional development, and provides researchers with opportunities, and time, to develop their research identity and broader leadership skills. We encourage managers to have regular career development discussions with researchers, including holding a career development review at least annually. The University provides opportunities for researchers to engage in leadership and management training to enhance their personal effectiveness, and to promote a positive attitude to professional development. We also actively support researchers through our use of mentoring. The University holds promotion rounds every two years and provides active support through the line management system, and additionally through the use of external consultants, to help promotion candidates prepare applications for promotion and also prepare for final selection interviews. Unsuccessful candidates are provided with detailed feedback on their promotion journey. In 2020, 3 staff were promoted to Professorial level, 1 to a Readership and 3 to Principal Lecturer (37% of total applicants).

The University is committed to ensuring equality of opportunity for researchers and providing an environment that supports that objective. All of our researchers are required to undertake equality and diversity training.

### **Postgraduate Research (PGR) Students**

**Research student environment:** The University has a dynamic, growing population of research students encompassing MRes, MPhil and PhD registrants. The number of research students has increased considerably from a total of 56 in 2012/13 to the current number of 97. Our intake of 16 PhD students in 2019/20 was 56% EU/International and 44% UK which is similar to the profile seen in recent years. Over the last 6 years the average number of applicants per studentship has been 14.7:1 reflecting a vibrant recruitment environment for postgraduate research at the University.

The PGR community has full access to all of the University's research facilities. The students integrate fully into academic life having full access to all academic staff, postdoctoral RAs, technical support staff in plant/crop/animal production, leading research facilities including a commercial scale mixed-dairy, arable and sheep farm as well as units for pig, poultry, beef and aquaculture research, a precision robotic-smart research dairy and food technology/engineering workshops.

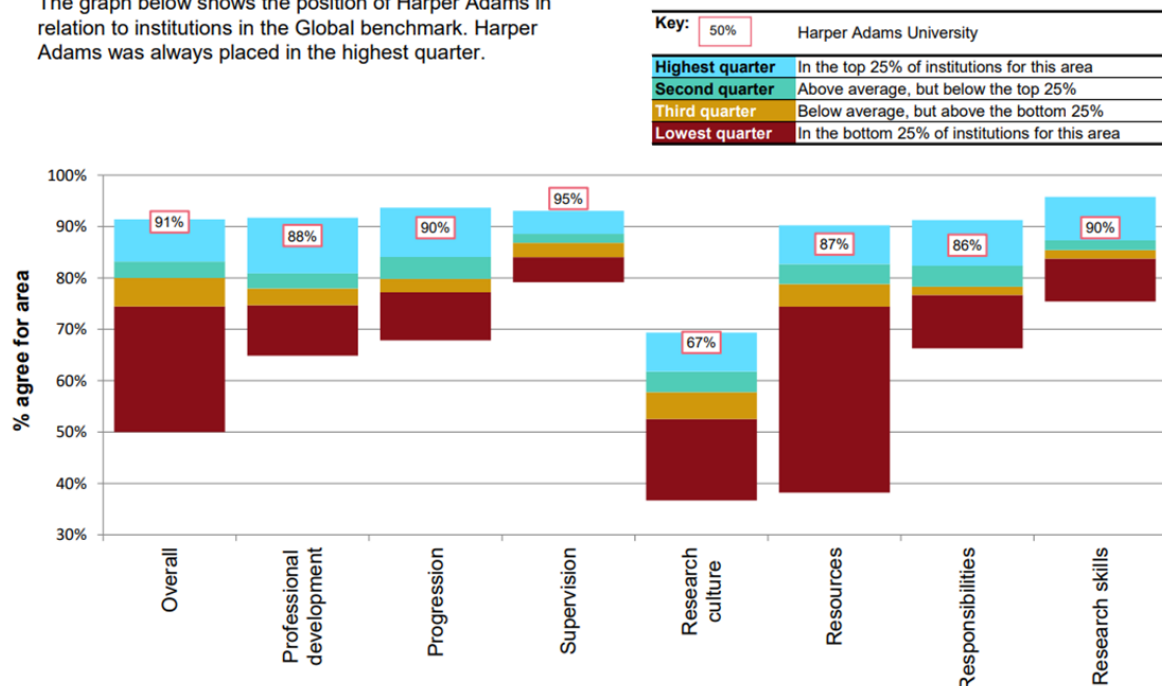
To ensure that the research environment is appropriate and remains so for the postgraduate research student population, the University produces an Annual Monitoring Report for Research Degrees which is considered by the Research Degrees Committee and the Academic Board.

During each annual reporting period the University monitors the effectiveness of its postgraduate research provision and the action items identified in previous year's Annual Monitoring Report for Research Degrees. This annual report provides the evidence base on which the Research Degrees Committee, on behalf of Academic Board, can judge whether awards standards and postgraduate research student experience are appropriate. The report takes into consideration the UK Quality Code for Higher Education - Advice and Guidance for Research Degrees. The report provides an overview of issues arising from: (a) evaluation of progress on previous action points, (b) changes made to research degrees award procedures, (c) final awards achievement, (d) issues arising from external examiners' reports, (e) student progression data, (f) student appointments, (g) matters arising from the Research Degrees Awarding Board (RDAB), (h) an overview of student satisfaction levels and (i) employment of students. It also identifies areas where work is in progress to address problems or further improve provision and offers proposals for further development, for the Research Degrees Committee to approve, if considered necessary.

MPhil and PhD students are also invited to take part in the annual national Postgraduate Research Experience Survey (PRES) conducted by Advance HE. In recent years, the university has been placed in the highest quartile for all sections with respect to the global benchmark data. HAU scores are shown in the diagram below:

### Areas of experience by quarters

The graph below shows the position of Harper Adams in relation to institutions in the Global benchmark. Harper Adams was always placed in the highest quarter.



**Support and generic training:** The University operates a comprehensive Doctoral Development Programme for PGRs which, for much of the assessment period, has been delivered as a two-week programme at induction and then throughout the academic year on Wednesday afternoons. A dedicated member of staff, the Researcher Developer, provides support and guidance for PGRs and coordinates the following training programme:

*Researcher Development Framework Planner:* The University subscribes to the Vitae Researcher Development Framework (RDF) Planner which provides a structured format for training throughout the duration of the studentship. The RDF Planner is designed to help students reflect on their achievements against the Vitae RDF. Training is delivered by appropriate academic staff and all resources are available to PGRs through the Harper Adams Learning Hub.

*Online Training:* As a small institution HAU made a strategic decision to fully engage with the 'University of East Anglia (UEA) Online Training Series' to optimise the benefits of research training for our PGRs. This programme offers research and professional skills training for PGRs in a 'live-taught' online format delivered via a virtual classroom. The training is organised into five modules spanning 62 scheduled sessions, each focused on a specific area/topic including Academic Writing, Qualitative Research Skills, Finishing your PhD, Teaching Skills and Quantitative Research Skills.

*Event Related Advice and Guidance:* In 2020, the University provided a PhD researcher guide to Covid-19 and supported PGRs to return to laboratory work as soon as it was considered safe to do so (PhD students were prioritised for return to campus). The University also gave extensions to registration periods when requested.

**Partnerships for research students:** The University has actively sought partnerships to support and develop research student opportunities:

*Advanced Training Partnerships:* HAU has been a partner in two BBSRC-funded Advanced Training Partnerships. The most recent was the Agri-food Training Partnership (AFTP) led by the



University of Reading, and involving HAU, University of Nottingham, Aberystwyth University, Cranfield University, Bangor University and University of Birmingham. This was a formal collaboration that delivered cutting-edge training including short courses and on-line learning for part-time Master's programmes and Research Degrees.

*Doctoral Training Partnership:* The BBSRC-funded Doctoral Training Partnership *Midlands Integrative Biology Training Partnership* connects five centres of excellence across the Midlands (Universities of Warwick, Birmingham, Leicester, Aston and HAU) to support the rapidly-developing Midlands bioeconomy. In addition to facilities listed elsewhere at HAU, MIBTP students can take advantage of the Midlands research infrastructure and the intellectual environment this provides. Collaboration between participating institutions enables cross-partner access for HAU PGRs to state-of-the-art facilities including the £>6M cryo-EM (UoL), £8M 1GHz NMR spectrometer (UoB - 2020), £1.5M MRI scanner (UoB), £0.7M 3-D cellular imaging system (UoW); £0.6M super-resolution multi-photon and dSTORM imaging system (UoL); £1.2M high performance mass spectrometry (UoB); >£2M multi-omics facility with mass spectrometers for proteomics, metabolomics and microbiomics equipment (UoB, UoL); £5M plant phytobiology facility (UoW). Joint supervision of PGR students within the MIBTP has provided a step change in interdisciplinarity capability and the research environment for HAU students.

**Student achievements:** Postgraduate students have contributed to a proportion of our submitted outputs (13%). Our PGR students regularly win prizes at national and international events. Examples include two PGR students coming first (£10k prize) and second in the European Farming by Satellite competition, announced in Paris in 2013. This competition was open to students and young people from across Europe with a total of 114 people entering from 25 different nations. PGR students have won the Worshipful Company of Poulterers research prize in 2015; the Royal Entomological Society Prize in 2016, the prize for best presentation (from >50) at the AHDB Postgraduate Seminar Programme; PGR students won third prize in an international open-air field robot contest, held in Slovenia in 2015.

A number of PGRs are in receipt of scholarships (e.g. Barham Benevolent Fund Scholarship, Faccenda Scholarship, Silcock Scholarship, John Oldacre Fellowship and Felix Thornley Cobbold Agricultural Trust Scholarship). The University also participated in the *Science Without Borders* Programme, hosting students from Brazil.

DLHE data for the University shows that 91.6% of PGR graduates achieve graduate level employment within 6 months of completion. Most graduates are employed in Lecturing, Teaching & Research e.g. of the 10 students who were awarded their degrees in 2019 all entered employment or continued employment with their existing employer, including 5 as lecturers in HE, an Outreach & Engagement Executive, a Postdoctoral Researcher, a Research Technician, a Postdoctoral RA and a Research Scientist (commercial sector).

## Equality and Diversity

**Policy:** HAU's Equality and Diversity Policy supports the University's commitment towards eliminating discrimination and promoting diversity and equality of opportunity in its practices, policies and procedures. It sets out provisions encompassing all areas of equality and diversity across the University and provides for the coordination and implementation of our strategic objectives in this area as set out in its Vision and Strategic Plan. The University continues to develop other policies to support this objective, and specific areas of equality and diversity, as appropriate. Our policy was developed in consultation with the University's main stakeholders, including the University and College Union and Staff Consultative Group.

The University is committed to promoting a culture and environment in which its students and staff are treated fairly and are not discriminated against without lawful cause, on the basis of race, religion or belief; gender (including gender reassignment); marital/civil partnership status; sex; sexual orientation; disability; age; parental, pregnancy or maternity status; social or economic

group. Victimisation is also prohibited under this policy, as well as harassment related to any of the protected characteristics.

The University complies with current anti-discrimination legislation as well as associated codes of practice or guidance issued by the Equality and Human Rights Commission and other relevant bodies. The University is committed to addressing barriers to equality. All of our staff, including research staff, are trained in Equality and Diversity and our “Avoiding Unconscious Bias” training is completed by staff and managers to support the continued elimination of bias from our people processes. We have embedded new guidance on gender neutral language into the recruitment process to ensure that no applicant is consciously or unconsciously deterred from applying.

The commitment to equality comes from the very top of our institution where gender equality is clearly evidenced through the make-up of the senior management team (four females, two males).

**Responsibilities:** The University, its staff and its students are all responsible for promoting and maintaining equality and diversity across the University and in all of its activities. The University’s governing body, the Board of Governors, has overall responsibility for ensuring that the University complies with the requirements of anti-discrimination legislation and in particular with the provisions of the Equality Act 2010 (“the Act”) and the general duty under the Act.

The University promotes the flagship Advance HE Aurora Programme. Aurora is a women-only leadership development initiative designed to enable a wide range of women, in research, academic and professional roles in higher education, to engage with leadership development at an earlier stage in their careers. Aurora combines education, mentoring and project work to provide a learning experience with an enduring impact. The University continues to see positive results in successful applications for promotion from Aurora participants in academic and professional service departments.

The University has worked on recommendations from expert external consultancy support, which was undertaken to establish what works to enable women to progress within the institution.

**3. Income, infrastructure and facilities****Research Income**

External research income for 2013-2020 was c. £23m, derived from a wide range of funding sources. Grant income consisted of a combination of UK industry, commerce and public corporations (38%), BEIS and Research Councils (23%), UK central Government bodies (19%), EU (9%) with the remaining 12% coming from charities. Internal funding supporting research over the same period has been c. £3.2m, mainly supporting PhD students, derived from QR funding.

**Infrastructure and Facilities**

The University has made a considerable investment of more than £22m in infrastructure projects to accommodate the increase in research activity since 2013, new appointments and an increase in PGR student numbers. Investments during the assessment period include the Elizabeth Creak Laboratory opened in 2017 (£2.5m partially supported by the Elizabeth Creak Charitable Trust) and an extension to the University's 'living laboratory' through the purchase of a further 92 hectares of agricultural land (£2.84m in 2018) bringing the total potential experimental capability to c. 630 hectares. Funding from the UK Government's Strategy for Agricultural Technologies was won to establish the Midlands hub of the Agri-EPI Centre to provide engineering and precision agriculture solutions for the Agri-Food industry and a 'precision' dairy for research on sensor technology and robotics (£6m in total on campus from a £17.7m UK government investment). With support from the Jean Jackson Trust, the University has also been able to establish a research glasshouse facility (£400k) and state-of-the-art entomology research facilities including controlled environment rooms for insect culturing and a research laboratory (£200k). Details of further investments are noted below.

The Harper and Keele Veterinary School (first cohort 2020) has been a major investment for the University (c. £10m capital and joint recruitment at steady-state of c. 70 staff). It will make use of existing, state-of-the-art University research facilities, including the commercial scale mixed-dairy/arable and sheep farm; robotic milking smart dairy facility; pig, poultry, beef and aquaculture research facilities, and a companion animal house which houses exotic and non-exotics.

**Examples of smaller scale infrastructure investments**

*Precision Dairy:* (users Rutter, Charlton and Beaver) £1M. The new dairy facilities (commissioned 2017) within Agri-EPI enable researchers, the dairy industry and agri-engineering companies to work together to develop the next generation of dairy housing and management and to test and develop sensor technologies. A key concept is developing technology to facilitate cow choice that this can improve milk production efficiency as well as improving animal welfare.

*Young Stock Facility:* (Sinclair, Rutter, Bleach, Beaver and Charlton) £500,000. Purpose built facility for the rearing of young stock to support the University's main ruminant facilities.

*Poultry Research Facility:* (Pirgozliev, Rose) £600,000. This state-of-the-art facility can operate as two large floor pens and can be further sub-divided into pens to facilitate replicated scientific experiments. Environmental-controlled rooms (for lighting and temperature) and a partitioned caged-laying facility allow replicated comparative studies. The facility also allows studies on poultry behaviour and welfare assessments of egg production systems and poultry meat production.

*Pig Unit Weaner Building* plus equipment: (PhD students) £295,000. Extension to existing pig research facility to support finishing of animals on-site.

*Veterinary Services Centre:* (existing and new Vet School staff) £600,000. The VSC is a purpose-built facility available for research purposes. The facility consists of eight consulting rooms and a

hydrotherapy suite. Two of the consulting rooms have the ability to provide a total black-out function, and are identical, which is necessary in behavioural research. The hydrotherapy suite is a state-of-the-art room with the benefit of both a pool and a canine underwater treadmill. The pool is fitted with underwater cameras projected onto large television screens above with glass sides allowing viewing from all angles.

*Applied Research Laboratory:* (PhD students) £180,000. Provided to further enhance research laboratory capacity and accommodate the increase in PGR student numbers.

*Aquaculture:* (Davies, Herath) £154,000. A state-of-the-art facility providing long-term research infrastructure that can be utilised for multidisciplinary industry and academic research and development. The fish tissue culture facility provides additional 3R-compliant research ability to test novel antimicrobial ingredients and feed additives.

*Anaerobic Digestion:* (Theodorou, Kirby) £84,000. The Agricultural Centre for Sustainable Energy Systems (ACSES) has a comprehensive laboratory for undertaking a wide range of anaerobic digestion experiments, from biochemical methane potential assays to bench-scale digestion trials. ACSES also has a unique pilot-scale anaerobic digestion plant (2m<sup>3</sup>) for commercial development work, aiding companies to trial products and bolt-on technologies with a smaller-scale replica of a commercial plant.

*Glasshouses:* (Back, Edwards, Hare, Hartley, Kettlewell, Monaghan, Vickers, Reade, Pope, Leather, Segar, Campbell, Roberts) £400,000. The glasshouse provides modern, futureproof research facilities for a wide group of academics. It is made from polycarbonate rather than glass, which allows for better thermal dynamics, making it more energy efficient.

### **Policies and practice in relation to research governance**

We aim to establish and promote good governance and ethical practice in the conduct of research. We encourage researchers to adhere to best practice relating to the ethical development, implementation and dissemination of research; to protect the integrity and reputation of our University; to protect the rights of participants and fellow researchers and to promote sustainable agriculture, enhance biodiversity and optimise energy use in an environment of finite natural resources. Researchers must demonstrate respect for the integrity of knowledge, respect for animals, and for the environment.

We adhere to *Rigour, respect and responsibility: a universal ethical code for scientists*, a public statement of the values and responsibilities of scientists, defined by the Department for Business, Energy, and Industrial Strategy as including anyone whose work uses scientific methods, including social, natural, medical and veterinary sciences, engineering and mathematics. The University also follows both the UUK Concordat to Support Research Integrity and the UK Research Integrity Office (UKRIO) Code of Practice for Research written on behalf of the University sector and providing a basis for the conduct of all research in academia. HAU also follows the Government led Joint Code of Practice for Research. This code lays out a framework for the proper conduct of research using 'best scientific practice' from the start of all research projects. Many funders are signatories to this Code. All staff and students carrying out social science research are required to abide by the Market Research Society (MRS) Code of Conduct. Researchers also adopt the principles of good research practice (*adapted from BBSRC Statement on Safeguarding Good Scientific Practice, 2016*) and acknowledge, through this process, the role of collaborations and other participants.

Researchers must comply with all legal requirements governing research, including the Bribery Act 2010, and the Animal (Scientific Procedures) Act 1986. In particular, they must ensure compliance with Data Protection Law. This consists of all EU Data Protection Directives, including GDPR, and all UK legislation (including the Data Protection Act 2018). All research data collection must conform to the GDPR2018 regulations and is expected to have a Data Management Plan.

In order to comply with the above the University's Research Office provides advice to researchers on contracts, ensuring compliance with legislation, regulation and best practice listed above. HAU also has a comprehensive suite of policies on research ethics, working with plant pathogens, and ensuring compliance with the Nagoya Protocol. Research governance is carried out for each individual project. Individual projects have to secure ethical approval from the Research Ethics Committee. Each project is reviewed blind by two appointed scrutineers in line with the University's policy and procedures for research ethics approval. All projects require risk assessment and depending on the subject require approval from Genetic Modification Safety, Biological Safety committees and Animal Welfare and Ethical Review Body.

The Technician Commitment is a sector-wide initiative led by the Science Council, supported by the Gatsby Foundation, to address key challenges facing technical staff working in research and to deliver greater status, profile and opportunity for the technical community in higher education. The University backed a pledge in 2017 to support our technicians who are critical to the success of the University and its research endeavours.



**4. Collaboration and contribution to the research base, economy and society**

Our research collaborations are generated at several levels to enable us to reach our research goals and contribute more widely to the economy and society.

**Engagement with UK and international partners**

A strength of our applied and interdisciplinary research is the strong connection of our researchers to industry, the professions and the policy-makers whom advise the sector. Much of the research undertaken is either directly funded or conducted in collaboration with industry partners or policy advisors. This relationship underpins the University's emphasis on problem solving research and allows researchers to make use of industry research facilities when required. The University has also established a wide network of University partners both within the UK and across the world. This has been in response to our research strategy which sought to widen our influence both within the UK and globally.

As part of its collaboration strategy the University is a partner in two Agri-tech Centres funded through the UK Government Agri-tech Strategy. The Agricultural Engineering Precision Innovation Centre (Agri EPI) brings together leading organisations in all sectors of the supply chain. Agri EPI, which is partly based at HAU, is becoming a world-leading centre for excellence in engineering and precision agriculture to benefit the livestock, arable, aquaculture and horticulture sectors. The core partners in the Centre are HAU, Scotland's Rural College (SRUC), Cranfield University, Harbro Ltd, Ag Space Agriculture Ltd and Kingshay Farming. A further 130 companies are now supporting the Centre through 'in kind' and cash contributions (to match the original £17.7m Government investment), including large supermarkets, food producers, farmers, processors and engineering and technology businesses.

The Centre for Innovation Excellence in Livestock (CIEL) is an innovation centre involving HAU and 12 other UK Universities/Institutions. CIEL brings together the food industry and academic researchers to transform the productivity of the UK livestock industry. CIEL was allocated £27.7m funding from the Government's Agri-tech Strategy to set up facilities across the UK, providing the livestock industry with world-leading access to research. Additional funding from industry and the participating research institutions will bring the total investment to £70m. HAU provides expertise and facilities for dairy, beef and poultry research for this Centre.

HAU also has an extensive portfolio of partnerships with industries including Saputo (formerly Dairy Crest) who invested £4 million to create a new innovation centre on the HAU campus, moving 40 R&D staff to the university. Dairy Crest and HAU, won the Most Innovative Contribution to Business-University Collaboration award at the Times Higher Education Awards 2016. The judges noted that, "Embedding research scientists in one of the country's top agricultural Universities was a pioneering collaboration in an industry with traditionally low R&D". HAU entered a research and development collaboration with MagGrow, an Irish SME based in Dublin, that strengthened the company's industrial research capability and experience for agricultural spraying coupled with the development of a spray testing facility. Internationally, HAU entered into a collaboration with India-based Tractors and Farm Equipment (TAFE) to develop advanced technological, agronomic and educational solutions for the delivery of sustainable food production around the world. TAFE, the world's third largest tractor manufacturing company in terms of volume, was the first business to take up residence in the Agri-EPI Centre Midlands Hub, on the university campus for a collaborative research and development project.

**Engagement within academia**

We take a proactive approach to promoting excellence, collaboration and impact in research and strongly encourage collaboration with both international and UK universities. In the period under review the University has established 29 new collaboration agreements with **international HEIs**. These are in: Brazil, Canada, Chile, China, the Dominican Republic, Germany, India, Indonesia, Japan, Namibia, The Netherlands, New Zealand, South Africa, Switzerland, Thailand, USA

(including Cornell and the University of California) and Ukraine. This marks a step change in the University's approach to internationalisation since REF 2014 and is of particular note as many of these agreements have been initiated by the international partners. One example of the outputs of these collaborations is the Science paper in 2016 (Early-branching gut fungi possess a large, comprehensive array of biomass degrading enzymes); another example is our collaboration with Kasetsart University to investigate and provide recommendations on how to improve the economic sustainability of small-scale rubber farms in Thailand, through Newton funding.

Our researchers are working in collaboration with a number of **national HEIs**. We have a collaboration with Leeds University and Barworth Agriculture to improve the accuracy of the 'AHDB potato cyst nematode (PCN) pallida calculator' which is currently used as an educational forecasting tool for UK potato growers. We have BBSRC funded collaborations with the Universities of Oxford, Birmingham and Reading on bacterial pathogen evolution and with NIAB-East Malling Research Station and Reading University on cherry pathogens. Our staff are part of the organizing group, with Universities of Reading, Royal Agricultural, Warwick, and Newcastle, of the Centre for Effective Innovation in Agriculture (CEIA). As well as these specific examples our staff currently have collaborative projects with the Universities of: Warwick, Keele, Greenwich, Durham, Reading, Sheffield Hallam, Hartpury, Leeds, Royal Agricultural, Surrey, Birmingham City, Nottingham, Leeds, Napier and Bristol.

### Wider influence and esteem

More widely, our staff take leading roles in supporting the national and international knowledge-base. A number of our researchers demonstrate **Academic Leadership**, through their prominent roles in funding panels such as being members of BBSRC panel B (Arnold), the Management Board of the BBSRC Horticulture Quality and Food Loss Network (Monaghan), the Review Panel for BBSRC National Capability 2019 (Leather) and Reviewer Board member of Animals (Bleach).

As well as **peer reviewing** for national funding agencies (BBSRC, NERC, EPSRC) our researchers are actively involved in reviewing for a number of international grant awarding boards from countries such as Norway, Austria, Sweden, Canada, USA, France, New Zealand and the United States-Israel Binational Agricultural Research and Development Fund.

Our staff hold positions on number of **editorial boards**. These include; Editor-in-Chief for Physiological Entomology and Associate Editor for Antenna (Pope); Editor-in-Chief Annals of Applied Biology (Leather); Insect Conservation & Diversity, Pest and Invertebrate Biology, Annals of Applied Biology (Leather); Plant Pathology and PLOS One (Arnold); Journal of Ecology (Campbell); Precision Agriculture (Lowenberg-DeBoer); Animals and Reproduction in Cattle (Bleach); Fermentation and Journal of the Institute of Brewing (Vriesekoop); Annals of Applied Biology, Pest Management Science and European Society of Soil Biology (Back); Journal of Horticultural Science and Biotechnology (Monaghan); Scientific Reports (Kettlewell); European Journal of Entomology (Segar); European Journal of Plant Pathology (Edwards); Journal of Sustainable Agricultural Management and Informatics (Behrendt).

Our staff are regularly invited to join the scientific organising committees and to be keynote speakers at prestigious international meetings and other **networking events**, which allow for development of national and international collaborative networks. For example, meetings where colleagues have been on scientific organising committees include the First African Conference on Precision Agriculture (2020); American Society of Microbiology annual meetings (2018-19); Symposium of Potato Cyst Nematode Management (2015 and 2019); the International Agricultural Science Congress, Turkey (2018), British Society of Animal Science and Advances in Nematology Conference (both annually). Colleagues have also been invited to speak at many meetings including; Pseudomonas, Malaysia (2019); XXII Colombian Congress of Agronomic Engineers, Colombia (2019); Dairy Europe (2019); EUCARPIA Leafy Vegetable Symposium, Czechia (2019); Science technology engineering economics for Digital Agriculture Conference, Australia (2019); Latin American Conference on Precision Agriculture, Chile (2018); IAFP European Symposium on Food Safety (2016 & 2018); the 50th Anniversary Congress of the Southern African Society for

Plant Pathology, Drakensberg, South Africa (2017); European Commission conference on Climate change and mycotoxins in feed and food: a challenge for feed and food supply and safety EXPO MILAN (2015).

Our staff play key roles in **learned societies and advisory boards** representing the range of disciplines in which we are involved. These include President of the International Society of Precision Agriculture (ISPA) (Lowenberg-DeBoer); President of the British Society of Plant Pathology (2019) (Arnold); President of the British Society of Animal Science (2016) (Sinclair); President Amateur Entomological Society 2017-2018 (Leather); membership secretary for International Society of Applied Ethology (Charlton); the Society of Microbiology representative for the UK Plant Sciences Federation (Arnold); committee member of the Midlands section of the Institute of Brewing & Distilling (Vriesekoop); Chair of Red Tractor Produce Technical Advisory Committee (2010-17) (Monaghan); AAB Plant Physiology and Crop Improvement Group Committee (2015) (Monaghan); member of the UK Expert Committee on Pesticides (Hare); International Network for Economic Research (de Aguiar); Programme Secretary for the AAB (Back); British Crop Protection Council Pests and Beneficials Expert Working Group (Pope); Scientific Advisory Board for the €18m Crop Optimisation through Sensing, Understanding and Visualisation project at University College Dublin (2018) (Kettlewell); Scientific Advisor on the Agriculture and Horticulture Development Board Sutton Bridge Crop Storage Research Advisory Committee (2019) (Kettlewell); Independent expert member of UK Cereal Mycotoxin Stakeholders Group (Edwards); Deputy Community Leader, International Society of Precision Agriculture Economics Community (Behrendt).