Future of Agricultural Technologies

– closed POST lunch briefing event

Tuesday 21st February 2019, 12.45 – 14.15, 1 Parliament Street, Room A
POST held this event for parliamentarians to discuss with experts the challenge of providing food using less land, with reduced inputs, and in the context of global climate change and declining natural resources and the contribution research and innovation can make to this, from building resilience in supply chains, to novel technologies, to engaging consumers to help change behaviour and improve nutrition. Focus was also given to discussing the interdisciplinary collaborations and research projects that could make a significant contribution to developing safe, sustainable food systems. The event was chaired by Neil Parish MP, Chair of the House of Commons Environment, Food and Rural Affairs Select Committee. Attendees heard briefly from seven speakers during the discussion:

- **Professor Sarah Bridle, University of Manchester**
- **Dr Niamh Forde, University of Leeds**
- **Dr Geraint Morgan, The Open University**
- **Professor Simon Pearson, University of Lincoln**
- **Geoff McBride, Science and Technology Facilities Council**
- **Dr Ben Goodall, Food Standards Agency**
- **Professor Simon Blackmore, Harper Adams University**
- **Dr Kelly Parsons, City University**

Lunchtime briefing summary

Neil Parish MP opened the event by highlighting the challenge of feeding a growing global population while reducing impacts on the environment, which may require not only producing food more efficiently but also changing diets. It would also not just be a challenge of providing food for wealthier consumers, but providing a choice of food for everyone, and any changes to diet would need to be gradual.

Geoff McBride. STFC employs an academic community of around 1,700 in particle physics, nuclear physics, and astronomy including space science; funds world-leading, large-scale facilities across a range of physical and life sciences, enabling research, innovation and skills training in these areas, such as the Diamond Light Source, the UK's national synchrotron science facility; supports multinational scientific collaborations including the building of the Atlas collider at CERN, the Square Kilometre Array radio telescope and with the European Space Agency; provides high performance science computing facilities for researchers; and funds research relating to the science and challenge areas of UKRI. In 2010, I was asked to attend the Global Food Security Programme Coordination Group, which comprises the UK's main public funders of agri-food research, which inspired the formation of the STFC Food Network+ based on the STFC multidisciplinary batteries research network.

Professor Sarah Bridle: I have spent most of my research career trying to uncover the nature of dark energy using gravitational lensing - the bending of light by dark matter – but currently half my research time is spent on agriculture and food, including applying astronomy techniques to image analysis in agriculture and leading the STFC Food Network+. The objective of the network is to create new connections between research and the agriculture and food industry that wouldn't have occurred without the network, and applying STFC funded research to food related challenges, including data science techniques. Astro and particle physics requires the analysis of vast sets of data

that has led to the creation of a significant STFC funded data analysis capability, which can be applied to agricultural production. For example, this capability has been applied to analysing high resolution monitoring datasets from crop fields to forecast yields and creating decision support tools for hydroponic growers.

Other STFC capabilities applied to food include the application of cryogenics developed for satellites to refrigerated supply chains in India, using high resolution X-ray imaging image on rice to determine where arsenic accumulates and seeing how potatoes swell up when cooked to determine the nano- to microstructural architecture of snacks to improve product performance. Raman spectroscopy has been adapted to address food fraud, to detect and quantify the adulteration of fruit juices and coconut water through the walls of containers, and advanced gas sensing technique, originally developed for radio astronomy research, that detects the natural microwave spectral emission signature of ammonia is being adapted to monitor agricultural ammonia emissions. Further projects to be funded will broaden the international collaboration aspect of the network and will encompass both food waste and aquaculture issues.

Dr Niamh Forde: My research has focussed on understanding how the uterine endometrium and the embryo functionally interact and communicate at the molecular level to establish successful early pregnancy and how stresses in the maternal environmental can lead to dysregulation and early loss of embryos. Pregnancy success in livestock is critical for milk and meat production and this project adapted STFC pattern recognition techniques, used to analyse astronomical data, to predict when an animal ovulates. This is being combined with drone-based infrared imaging technology to rapidly survey livestock to detect the heat signatures before an animal ovulates to inform artificial insemination strategies. The project is currently focussed on dairy and beef cattle, but these technologies could be harnessed for other species of livestock and in other countries. Additional projects are looking at how environmental stresses can affect the maternal environment in the uterus and how this can have an effect on the offspring including enhancing susceptibility to infection, general life course health and robustness at the molecular level. This will allow us to produce more meat and food products in a sustainable and robust way and has important implications for human health as well.

Dr Geraint Morgan: Space & Planetary Exploration pushes the boundaries of science and technology; for instance, if you are to build an instrument to analyse the composition of another planet then you need to make them small, light, robust (capable of surviving large shock and vibration loads), extremes of temperature and radiation, use little power and energy yet provide us with lab-quality data that allows the science questions to be answered. I was part of the UK team that developed the Ptolemy instrument on the Rosetta mission that landed on a comet in November 2014 after a 10 year, 4-billion-mile journey. By sniffing the dust released on our first bounce we were able to show that the building blocks of life, that we are all made from, are on a comet. Ptolemy required a large multi-disciplinary team of scientists and engineers to shrink something that is the size of a family car down into a shoebox. Having such a multidisciplinary team has allowed us to apply collective know-how to solving problems here on Earth, from developing an award winning air monitoring system to be used on all future UK submarines, to mimicking dogs in sniffing cancer, detecting bed begs in hotels through to helping the Scotch Whisky Research Institute detect fake and adulterated whisky to protect the brands of companies in the biggest export sector in the UK.

The STFC Food Network+ has provided the team with a broad range of stakeholders in the food sector with challenges that need solving and allowed us to explore a pipeline of projects with a view to developing solutions to real-world problems that can be implemented and adopted commercially. Along with Cardiff University, we are developing an affordable sniffing device to determine the shelf-

life of bagged fresh produce, such as rocket salad, broccoli, cabbage. Up to 30% of fresh produce goes to waste each year, if we can develop new tests that can be used throughout the value chain then we can potentially significantly extend the shelf-life and reduce waste. The UK avocado market is worth £200m pa and growing exponentially, but 1 in 5 avocados is damaged by a fungal infection inside, so £40m worth of avocados shipped to the UK are thrown away and globally this figure is in the billions. Along with Greenwich University, we are identifying markers for a new sniffing test to fingerprint the most common fungal infections that cause browning. Our most recent project is exploring if we can develop a detector that can find Camplylobacter on chicken farms much earlier. There are 300,000 cases of food poisoning each year in the UK, 15,000 hospitalisations and 80 deaths, with 7 out of 10 cases believed to be caused by Campylobacter, which could be reduced by removing chickens from production earlier or treating them.

Professor Simon Pearson: The cross disciplinary research project is looking at how new technologies can address the challenges of reducing agri-food greenhouse gas emissions, with a particular focus on agri-robotics. I have worked for 15 years in the industry and run four farms and have diverse range of agri technology applications including robotic systems, automation, energy control and management, food safety systems, novel crop development. The project will consider the whole of the agri-food chain from farm to fork, which employs 3 million people and is responsible for 24% of GHG emissions. The sector has low productivity, with agricultural productivity flatlining for over 5 years, partly due to the reliance on seasonal migrant labour.

There are also a range of health disbenefits arising from the food being produced, including chronic diseases arising from obesity, such as diabetes, and food poisoning. While the research programme is seeking to be interdisciplinary, it is notable that farmers already are, and have to have skills ranging from chemistry, engineering and life science to business management. They will also have to be able to use agricultural data in order to use agri-robotics; this research looks at the interoperability of flows of data and the use of machine learning and AI to facilitate this, so that consumers can access data on the origin of products at one end of the agri-food chain and farmers understand how consumers use products at the other. The governance model for agricultural data will be critical, including who owns it, stores it, manages it, processes it and its interoperatability.

Professor Simon Blackmore: The current approach to agricultural machinery is not fit for purpose; the trend towards economy of scale means tractors and equipment are getting ever bigger, forcing farmers to farm in a way that requires large inputs of energy, fertilisers and pesticides. However, robotics offers the possibility of moving to smaller machinery to allow farming at the scale of plants or organs of livestock, which does not require new pesticides to be developed or genomics to improve productivity. For example, small robots can be used to remove weeds, plant seeds or scout areas to determine readiness to harvest. I am currently working with a number of companies to develop scouting robots that can survey 10,000 heads of broccoli, applying engineering principles to production to increase productivity.

Using robots to apply pesticides only where they are needed could be the basis of moving the legislative approach to chemicals from hazard to risk; for instance, 1 gram of glyphosate per hectare could be all that is needed to achieve effective weed control. Robots can also use lasers for weed control, it only takes 7 watts of energy to kill a weed, which are recognised using a camera. Another area robotics can improve productivity is selective harvesting to reduce food waste, conventionally harvested vegetables may incur 20 to 60% losses of crops that do not meet quality standards. By contrast, robots can identify what plants are at the appropriate stage for harvesting and only pick exactly what is needed at the right time. Gardeners and allotment holders do not crop vegetables in

one go because of the wastage involved, it is only current human labour-intensive approaches that require farmers to do so.

Dr Kelly Parsons: There is growing recognition of food as part of wider more complex system than merely the food chain from production to consumption and disposal, including interactions with environment, health, society. In policy terms, links between food production and environment are more firmly established than links between food production and health, and social issues (e.g. hunger, worker livelihoods). Taking a whole food systems approach is increasingly being pushed for, which entails looking at connections between the different parts of a system, understanding where activities in one part of the system impact - intentionally or unintentionally - on another, and where there is feedback, or broken feedback, between parts of that system. One of the reasons systems approach to food policy is challenging is it requires making connections across: historically-isolated policy areas, such as agriculture, innovation, environment, health; different levels of government, global, regional, national and local; and public, private and third sectors activities. This has led to interest in different approaches to governance (see Tackling Food Systems Challenges: The Role of Food Policy), with three main ways food governance is evolving:

- Integrated food policies that join up different ministries and levels, such as overarching national food policies, like England's National Food Strategy and the cross-cutting food policies being developed in Scotland, France, Canada.
- New governance mechanisms at national, European and global level, such as: the Cabinet-Sub Committee on Food, the Food Policy Task Force, the Defra Food Policy Unit and the Council of Food Policy Advisors that previously existed in the UK; the structures in place in Brazil to link work on food and nutrition security, including an exclusively governmental body formed by ministers, and an advisory body, CONSEA – the National Council on Food and Nutrition Security, including civil society and government; the proposed Statutory Food Commission in Scotland; Food Policy Councils at the city level, based either inside local governments, or in civil society; the proposed European Commission Vice President for Food Systems; and, globally a framework on food systems akin to IPCC is being discussed. Along with connecting food-related policy these often have an increased focus on 'good governance' – making food policy more transparent and participatory.
- Leverage Points to address multiple food systems goals. Suggestions made by the Centre for Food Policy in the report for the Austrian Presidency of the EU on healthy and sustainable food systems is to look for opportunity spaces to link up multiple food system policy goals (health, environmental and economic) in one particular lever, such as procurement, or supporting innovative small enterprises to bring healthy and sustainable food to deprived neighbourhoods, there are many examples of good practice. There needs to be thought about how agri-tech can support or impact these kinds of broader goals.

What does this mean for food governance in England? One of the pieces of work the Centre for Food Policy will publish later this year is qualitative research on how joined up governance is in the UK, looking at what cross-government work is happening, and what mechanisms or structures there are in place to support it. This involved interviews with officials across departments and outside stakeholders, to find out who is doing what with who on food. This should create a baseline to inform ideas on how food governance might be done differently in future, both in terms of better integrated and more inclusive of outside voices (particularly important with agri-tech developments that may need consumer buy-in). There are examples of existing cross-government working; the Childhood Obesity Plan is hailed inside government as a kind of cross-cutting policy exercise not seen before on food, and other examples include: anti-microbial resistance; Government Buying Standards; Health and Wellbeing and Planning; Soft Drinks Levy; and Brexit. However, the interviews

also raised examples of disconnects such as between health and food production, farmers and consumers, obesity and hunger, and domestic food production and trade. To build on the cross-cutting working, with wider food systems thinking in mind, formal mechanisms to join up work on food systems will be necessary to move beyond the joining up happening on specific programme-based working groups and personal connections. There is the Food and Drink Sector Council, but does it have the right remit and membership to address food systems challenges in the broader sense? There is no institutional home for food in the current set up, to connect work, broker interests and create a vision for food, as well as a lack of agreement on what bits of system are or could be connected, with different perspectives, inside and outside government, and across government. The forthcoming National Food Strategy is great opportunity to address these and build on work already happening, but research is needed to support food systems through governance, including:

- Deeper analysis of connections between policies addressing food systems, but bringing together disciplines and voices, such as on potential for linking agriculture and public health, with interrogation of this informed by farmers, agricultural economists, public health experts and ecologists as the connections are more complex than is often portrayed.
- Exploring how to build understanding and capacity within government on connected nature of food systems and policies that address them.

Ben Goodall: I work as part of CSA team in the Food Standards Agency, which seeks to ensure the best scientific evidence is effectively used in food policy. The simultaneous health and environmental pressure that our food system is under is a "wicked problem". There are some really interesting activities currently going on to connect a holistic, balanced view of the food system evidence base, and this joined-up approach is crucial:

- Defra has launched a "Systems Programme" with a Fellow leading each of 5 areas: rural land use; food; air quality; marine; and waste, and a 6th Fellow to bring them together.
- UKRI is launching a £50m Strategic Priorities Fund Programme on a "Food Systems approach to healthy people & healthy environment"

Both are multidisciplinary, and I think it's important to note the latter recognises our food system is a socioeconomic challenge as much as anything, and also that Defra, DHSC and FSA are on its Governance Board. Associating system changes to individual programmes is very difficult but the SPF will be monitored and evaluated against Governmental obesity & emissions targets. What's more, the timing of this evidence base support of both parallels well to the policy push from development of a National Food Strategy led by Defra's Non-Executive Director, Henry Dimbleby.

The UK meat industry is challenging and competitive, delivering over £4bn to the economy annually. For a further idea of scale this translates 1 billion chickens, 10 million pigs, 2 million cattle pass through the system in the UK each year. On a line of one of the fastest facilities, 172 chickens pass per minute. 2018 saw several high-profile incidents that challenged both the FSA and the industry, and in response the FSA recently completed a cutting plant review which acknowledged the need for system modernisation for improved consumer trust. In one form of another, we inspect as the transport arrives at an abattoir all the way through to when the product reaches the consumer but Official Controls in abattoirs is effectively a Victorian system involving someone standing there with a knife, visually inspecting a carcass.

Dr Sonal Choudhary and Dr Julia Heckenast, both in attendance, are the driving forces behind this but the FSA is currently working with the STFC to look at not only the application of cutting-edge innovation in the most integrated/advanced sites but modular innovations to support the industry

baseline. This aims to aid not only our delivery of official controls but further turn network research interest to support the industry in own right. A team of five academic experts (led by Dr Sonal Choudhary, STFC Food Network+) have been appointed to consider how possible research from the STFC projects can be applied. Sonal and her team of 5 academics are conducting an independent study, visiting sites from Llanelli to Scunthorpe with our help to assess where STFC skills can be best applied and we hope to co-design several pilot projects in the coming months in response. This is what I think is a really positive, targeted, responsive interaction in support food safety and system trust. Zooming back out, it's a very challenging but incredibly interesting time to be working at the evidence/policy interface and as new process, new evidence and new assurances come further into play we need to take a balanced look at our policy response.

Discussion:

- The issues around research and adoption of novel foods was raised, with the consumption of insects raised as an example. The challenges for start-up companies in this are were highlighted, such as Entocycle, based at London Bridge, which is developing processes to produce insect protein under controlled environment conditions using automation, artificial intelligence and machine learning increase productivity efficiencies. The protein produced is used in animal feed. The production of salad by controlled environment farming in underground tunnels in London was also noted.
- The difficulties of implementing robotics on farms was highlighted, particularly the cost-effectiveness for farmers for investing in robots. The main drive for robotics was to increase the efficiency of production by allowing more of the processing to take place on the farm, which should bring back some of the profits that are currently being realised by processors further down the production chain. For example, via harvesting robotics that allow grading and packaging in one operation.
- The difficulties of producing food that is healthy, tasty and wanted by consumers was discussed. Any system changes will ultimately be dependent on understanding and the ability to positively influence consumer choices. The Quadram Institute are looking at strategies to improve health through food innovation, including addressing age-related chronic diseases such as gut inflammatory syndromes, cardiovascular disease, cancer and cognitive decline, through advances in crop genomics to develop new varieties with enhanced nutritional qualities. They are also researching the chemical composition and physical structures of foods, which determine the rate of digestion and passage through the digestive tract, and the absorption of nutrient within the small and large intestine. It is critical that research takes a systems approach, considering the impacts and benefits from food across the full pathway from soil to sewer.
- The obstacles to getting the current strawberry picking robots under development from the lab bench to field were discussed. Crossing 'the chasm of death' was particularly challenging for new robotics start-ups, which struggled to attract investment. Investors are unwilling to take risks on such start-ups because of the way banks and investment finance undertake risk assessments and UK venture capital demands ownership of a substantial proportion of companies. There is also a lack of engineers with the relevant skills; for example, 25 engineers are involved in the strawberry picking robot project at the University of Lincoln, out of a possible pool of 40 suitably qualified people within the UK. The role of UKRI in producing people with relevant skills via PhD's will be critical. Given that the engineers are highly paid and there is a constant churn of individuals a much bigger pool of talent is needed.
- It was queried how far advanced laser weeding robots were. Syngenta funded a 3-year project and a robot has been developed that can recognise 26 weed species, but the initial model was

too slow. A faster model that can also recognise and remove black grass from cereal crops is now being trialled. It was suggested that the 36m boom sprayer would be in use for awhile yet, as even if herbicides could be replaced by robots there would still be a need for fungicides and insecticides. Only one problem can be solved at a time, but if there was a better understanding of diseases, the requirement for prophylactic treatments would be reduced. Spatial modelling of microclimates to track pathogens could limit treatments to where they were needed.

- The question of what the priority for Government funding mechanisms should be, such as the Industry Challenge fund, was raised. Data ownership has already emerged as an issue for farmers, which is only likely to grow as a challenge as machine learning is applied more widely to agriculture. It is notable that around 210 data governance models exist for healthcare, but none of them work properly. There needs to be trust in governance and the industry is beginning to understand the benefits of data sharing – it doesn't require regulation, but industry needs to be able to work together on interoperability, which the FSA has been showing leadership on. The Office for AI is also currently looking at data governance. The scope to use data better in the food industry is immense and integrating this data with those of other sectors, such as healthcare is a top societal challenge. Defra have published 12,000 datasets and have retained an STFC data fellow to show the potential data, such as the Crop Map of England (CROME), which uses 32 million hexagons that provide sufficient resolution for useful information while avoiding commercial and privacy issues. Transformation of the food system can be driven with data, but there needs to be clarity about the questions that data needs to answer globally and, in the UK, and data in siloes will need to be joined up in the private and public sphere.
- Strawberry growing robots will need two or three years more of development before they are ready for market and are likely to be expensive. By contrast, more robots could be sold to the cereal sector reducing the cost of units. Going from proof of principle to marketing robots will always be difficult and expensive, but the Government could do more, such as funding pilot farms for robotic technologies and feasibility studies. The existing agricultural machinery manufacturers are putting more machine learning and AI into ever bigger machines but are focussed on the US market.
- The need to capture the moment for defining the link between food and the environment as a public good was discussed, with environmental payments influencing how crops are grown. Any dietary change objectives will need to be co-produced with the public and interventions should be stratified to take account of different socio-economic needs and limitations. An approach that works backwards from economic, social, health and environmental outcomes through the food system would have more traction in Government

Neil Parish MP drew the event to a close noting the need and challenge of joining up the food system.