

THE FUTURE OF FOOD 2040



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PREFACE

Over the next 20 years, the UK farming industry will undergo significant changes in policy, markets and consumer demand, the likes of which haven't been seen since the introduction of the 1947 Agriculture Act. It is a time of challenge but also a time of great potential opportunity.

To help build a vision of what our industry will look like in 2040, what macro trends we can expect to see emerge, and what this means for British food and farming, we have produced this report which contains a high level scan of the horizon and its impact on the sector. The aim is to provide useful insights to help British farming gain a head start to adapt and evolve, as well as anticipate those opportunities so they can be developed to the full.

The prospect of taking such a leap into the future was, at first, quite daunting given the uncertainty of Brexit in the immediate future which, depending on the outcome, has the potential to change the trajectory dramatically for individual businesses and our industry as a whole. However, what was striking was that during the many expert interviews undertaken to shape this report,



the focus quickly shifted away from the immediacy of Brexit to the macro global challenges for the future of food.

For example, global population size is set to increase from nearly seven billion today to eight billion by 2030; the UK population alone is projected to increase to more than 74 million by 2039. The 2011 Foresight report on the Future of Food and Farming stated



that there will be huge challenges to the global food system between now and 2050 – notably water scarcity and the impacts of climate change. The global population will also become older and more urbanised, both of which will impact on food consumption patterns and agriculture. The unstoppable pace of technology continues to revolutionise our world, but it is a world that is becoming more volatile, not just climatically, but also economically and politically. Inside or outside of the EU, our food system cannot be shielded from all of these pressures.

Many of the changes we will see in farming and food production in the future will be driven by these global influences and Brexit will, in many cases, amplify and accelerate these existing long-term trends. Therefore, given the inherent complexity of scanning this environment, this report has assumed a “middle ground” whereby existing macro trends will largely continue along their current trajectories, but potentially at a faster rate than if Brexit had not happened.

To produce this report, I interviewed more than 50 industry leaders and commentators, farmers, scientists, environmental groups,

government representatives, retailers and economists – in the UK and beyond. I am grateful to all those who took the time to speak with me and for the many hours of thought-provoking and insightful conversations.

To capture the breadth of our sector, the interviews and resulting report were broadly structured around four key themes, namely:

- What we'll be eating;
- How we'll be producing it;
- How this will impact on British food and farming;
- Opportunities for new markets.

What I personally took away is that while 20 years may seem a long way away, planning for that future must start now – business as usual will not be an option. Perhaps it is not surprising that, whatever future scenarios play out post-Brexit, the most critical ask from this report is the need for an enabling future domestic agricultural policy which allows our farmers and growers to have the

best possible tools and support for their businesses to be able to adapt and take advantage of what opportunities present themselves over the coming years. The NFU's work to outline what is needed in any new domestic agriculture policy has already taken significant steps to develop policy priorities covering three cornerstones, namely productivity, volatility and environmental measures. These priorities map well onto some of the key emerging future needs that have been identified in this report.

There can be no rights or wrongs with such a future scanning exercise, and of course there were outliers and differences of opinion. Much may not surprise you and some you may disagree with, but this report attempts to give an honest summary of the destination where those discussions, on balance, eventually led. And, perhaps most importantly, it triggers the start of a timely debate for the food and farming sector.

Dr Andrea Graham,
NFU Head of Policy Services



INTRODUCTION

Farming and food production is on the brink of a revolution which will see the food we eat and how we produce it undergo a huge change. Advances in technology and the challenges of a changing society are already creating new opportunities for the sector as people's preferences for what they eat and how they buy it shift on a scale perhaps never seen before.

Inherently, farming is a forward looking and progressive industry that has always been an early adopter of technology. As the world's population continues to grow, ways have to be found to produce more food on the same amount of land while reducing farming's environmental footprint. Technology has a key role to play in helping us achieve this while also addressing some of the bigger social issues like ending hunger and tackling health problems. British farmers have a real interest in producing the raw ingredients which underpin a healthy lifestyle and helping to solve some of these national and global challenges. This type of innovation – precision agriculture and developing technology – will also help us achieve our ambition of ensuring farming is making a “net zero” contribution to climate change by 2040.

Despite the multiplicity of scenarios covered in this report that may play out over the

next 20 years, and the vast array of different farm business models both now and in the future, three common denominators are identified that will define the successful farm enterprises of 2040.

- Risk management – managing the increasing exposure of farming to risk and volatility by embedding resilience into the business model and accessing the right data and financial tools to help them.
- Transparency – being able to stand up to the intense scrutiny of an increasingly demanding customer and the exposure made possible in an increasingly transparent food system.
- Business sustainability – smart, professional rural businesses knowing and increasingly anticipating their end market. Making the most of marketing and entrepreneurial skills used in combination with productivity-enhancing innovation and technology to achieve sustainable outcomes.

Alongside these measures, we need a new consensus on the role of food in society. This is why last autumn the NFU published the 'UK – a nation united by food' document to start the conversation on the future of food and farming. I believe that four themes should

guide food policy in the decades ahead: the moral imperative to produce food, health and nutrition, integrity and standards, and working with nature – and work based around these themes is ongoing.

But I'm convinced too that farmers must also work within natural constraints to deliver the food we need. This report shows that expectations of farmers will only grow both in their production of high quality, fresh, nutritious, affordable food while also respecting and enhancing the natural environment. The publication of the NFU's 'United by our environment, our food, our future' report last December highlighted the good environmental work farmers are already doing as well as the challenges we still face, with the aim of inspiring farmers and growers and giving them a greater sense of ownership of the issue

Agriculture has a bright and innovative future. But to ensure we are able to take full advantage of the technological advances that are on the horizon it is crucial that farm businesses are not only given the support they need to survive and thrive now, but they start to plan and prepare for the future. Failure to do so will mean these advantages and opportunities are simply grasped elsewhere and risk both the UK's current and future food security.



We are living in an increasingly volatile world and agriculture, by its nature, is an industry that is exposed to climatic and market volatility. As the UK looks to develop new trading relationships there is significant potential for volatility to increase as markets are increasingly exposed to global factors like weather, pests, disease and trade relations. It is vital there are measures in place to ensure UK farming can ride out these volatility storms, as well as to underpin skills development and knowledge exchange so farmers can better deal with these issues.

Evidence also suggests a growing gap in agricultural productivity growth rates between the UK and other developed nations and while these have been attributed to a variety of reasons – falling rates of publicly funded research and development; reductions in the patenting of private research and development; and problems in the uptake and transfer of farm practices – it is essential that farmers are involved in the development of any new productivity measures and interventions to ensure they are relevant to the sector. Simply put, any measures aimed at increasing productivity have to boost efficiency, resilience and profitability.

Supporting farms to manage price volatility and improve productivity also puts farmers in a better position to maintain and improve the UK's environment, manage our natural resources more efficiently and reduce agriculture's environmental footprint.

British farmers and growers provide the quality raw ingredients that supply our safe, traceable food supply chain, one which is the envy of the world. British farming underpins the UK's food and drink sector, which today is worth £113 billion and employs nearly four million people. Both now and in the future, one simple fact remains: food is a fundamental of life and the consumer will remain at the heart of all we do.

Minette Batters,
NFU President

To enable British agriculture to take full advantage of the future opportunities outlined in this report, a number of specific policy interventions will be needed. These are in addition to free and frictionless trade with our nearest markets in the EU, as well as for the industry's workforce needs to be met after Brexit. Government will need to:

- Fully embrace a domestic agricultural policy that addresses the fundamental challenges of volatility, productivity and the environment.
- Factor in proper transition time to exit the current Common Agricultural Policy framework, with no rushed false starts. Platforms and systems must be fully tried, tested and fit for purpose before roll out.
- Actively encourage improvement in market information as a prerequisite to developing market orientated risk management tools in the UK.
- Invest in innovation and specifically support farm businesses to address the productivity challenge by providing targeted investment, supporting research and development, and incentivising the adoption of technical advances that strengthen resilience within the farming sector.
- Consider intervention to encourage the adoption of open data principles and ensure competition and a rich variety of tools and services are made available to the sector, and that data is not just the domain of a few major players.
- Ensure that we have an enabling regulatory regime that is fit for purpose, effectively supporting productive agriculture, production for the domestic market, and trade in agri-food products with overseas markets, while protecting the environment and the public. It will need to be science and evidence led with proportionate, risk-based approaches to encourage innovation and improve competitiveness.
- Ensure that any funding for public goods is universally accessible to farm businesses, flexible, practical and with a proportionate level of administration and auditing.
- Ensure that rural communities have access to the right technology infrastructure and planning framework to thrive and benefit from new business opportunities and realise their potential for advances in productivity.



DIET:

WHAT WE'LL BE EATING

The food British farmers produce will be dictated by what people in this country, and overseas, want to eat. As a result, significant shifts in eating habits have the potential to have a profound impact on farm businesses. The way the retail sector evolves will also change the way farmers work with their customers, both directly and indirectly. Insight into future trends will help farmers anticipate, and adapt to, future market demands.



Diets may change – but slowly:

Diets are notoriously difficult to predict, but there is unlikely to be dramatic changes in our diet in Britain over the next 20 years. While fad diets will come and go, and consumers will continue to seek out new and novel taste experiences, change is often very slow due to ingrained social and cultural influences. So, there is likely to be a simple and more gradual continuation of existing long-term established trends rather than a revolution. The more dominant long-term trends may reflect lifestyles and the ageing population of the UK. According to the Office of National Statistics by 2037 24% of the population is expected to be over 65 (in 2017 it was 18%)⁽¹⁾. The shift to dish-based meals and away from meals where a primary protein has been the focal point is likely to continue, along with the drive for convenience. The average time spent preparing a meal has dropped from 60 minutes in 1980 to around 30 minutes in 2016⁽²⁾, according to Kantar Worldpanel. The UK's food to go sector is set to grow at twice the rate of overall grocery retail, with IGD predicting growth from £17.8bn in 2018 to £22.8bn by 2023⁽³⁾.

Health becomes a key ingredient:

Personalisation of food choices and the health agenda will grow, along with more diverse diets. While practicality, price and taste will remain key drivers in food choices, health as a reason for choice is set to grow, according to the Agriculture and Horticulture Development Board (AHDB)⁽⁴⁾. In the five years to 2017, there was a 14% increase in the proportion of food served at home specifically chosen for health reasons, according to AHDB and Kantar Worldpanel⁽⁵⁾. With the UK on course to be the most obese nation in Europe by 2030 according to the OECD⁽⁶⁾, it's not surprising that diet-related health concerns, and the pressure this will put on our health services in the years ahead, will dominate the future food agenda. Meanwhile, the dramatic drop in the cost of genome sequencing will open up a wealth of possibilities around setting personal dietary goals linked to your own personal nutrition and health needs or food intolerances.

Cooking goes back to basics:

While the UK's food-to-go sector is predicted to grow, it is possible we could see a renaissance in "cooking from scratch" which could slow the trend. Moves towards "fresh" and "natural" driven by the health agenda are already starting to emerge, according to AHDB⁽⁷⁾ and it is possible this will encourage a return to more cooking at home. Developments in home appliances and innovation, allowing home cooking to close to restaurant quality, could also fuel this trend. An interesting example of the shape of things to come is the recent rise in the use of sous-vide⁽⁸⁾ cooking techniques – a staple of the service industry for many years, but now becoming more widely available and allowing perfect steaks and lamb shanks to be served up at home, but still feeling like home cooked rather than a ready meal.

Meeting up for a meal:

With information from the Office of National Statistics⁽⁹⁾ suggesting many families becoming more fragmented in future and more British households only having one or two people, this will change how people eat. More communal eating may emerge as a means to regain social interaction, particularly in the younger and older age groups. Greater fragmentation within society may also occur as the gap widens between different economic classes, which could impact on diets, according to research from the University of Sussex⁽¹⁰⁾.



Supermarkets as “food theatres”:

We will see the major retailers’ market share squeezed and the rebirth of physical stores as “food theatres” with artificial intelligence playing a central role in home restocking systems. Food will be increasingly purchased online, more frequently and more on the go. IGD has forecast that big-format stores will continue to lose market share⁽¹¹⁾. The existing big retailers will remain part of the shopping mix but with some new players on the block disrupting the market and fuelling change in the fast-moving consumer goods value chain, beyond the impact of the discounters⁽¹²⁾. Research from RBS shows changes in retail habits mean retailers across the board are already having to re-evaluate their store portfolios⁽¹³⁾. But British consumers will still like the experience of shopping and physically seeing, feeling and smelling goods and so it’s likely that the physical out of town supermarket store will need to take on a more “food theatre” role as it becomes less important as a purchase outlet for the major weekly shop⁽¹⁴⁾. The increase in online purchasing and automated smart home technology restocking systems may reduce opportunities for active customer engagement and for spontaneous discovery of new products. The view of the industry experts interviewed for this report was that we may also see a shift towards “subscription buying”⁽¹⁵⁾ direct from the manufacturer or producer to cut out the costs of the middleman, which will further challenge the big retail brands and offer potential for those farm businesses able to take advantage.

Inspiring British food will inspire shoppers:

The consensus view of experts interviewed for this report was that British shoppers will continue to want to feel good about the food they buy and eat rather than necessarily understand and know the detail. Just because people will be able to access more information in the future, this will not necessarily mean they will have any greater engagement. Attention span and time will be increasingly challenged with the explosion of information available to people. People are already bombarded by (sometimes conflicting) food news and messages from around the world and the nuances and points of difference around British production systems can get lost among global stories. Research from AHDB shows continuing strong support for British food and food producers and a strong association with higher quality⁽¹⁶⁾. While future support for, and trust in, British farming will endure, consumer reports from AHDB suggest that ultimately it will be high quality, safe, affordable and, importantly, inspiring food that will drive people to buy British, and not sentiment⁽¹⁷⁾. IGD research into the Millennial shoppers of tomorrow (currently aged 18 to 25) backs up this point and suggests these future consumers will expect “better products, prices, more product diversity and improved services, along with wanting meaningful experiences and inspiration”⁽¹⁸⁾.

Meat joined on the menu by insect protein:

People will continue to enjoy eating meat and it will still be seen as a good source of protein and vitamins, as well as continually delivering on one of the key drivers of purchasing behaviour – taste. Increasing resource and energy costs, and pressures from climate change, may drive up the cost of meat, but it may also create some opportunities in terms of differentiating on quality and premium. But there is no room for complacency from the British farming sector. In-vitro meat and insect protein may well grow in popularity depending on advances making these protein sources more palatable, and the ability for them to be produced cost-effectively at scale. There has been considerable research into the potential contribution that insect protein could make to food systems of the future⁽¹⁹⁾ including by the Food and Agriculture Organisation of the United Nations (FAO), and cricket flour is already being used as a way of integrating protein into bakery goods. While these products and other replacements, such as dairy alternatives, may be freely available, “normalised” and integrated into our diets, it is unlikely they will dominate the shopping basket and be a direct replacement for the vast majority of British people. The increasing popularity of more flexitarian diets (diets that are predominantly vegetarian with occasional meat and fish consumption) is likely to continue, with 41% of meat eaters currently classified as “flexitarian” and the percentage of ‘meat-free’ evening meals on the rise in Britain, according to research from Kantar Worldpanel. But this increase in “flexitarianism” does not necessarily signify a shift towards alternative protein sources, such as pulses, and might provide some opportunities for product development, according to the AHDB⁽²⁰⁾. However, the FAO⁽²¹⁾ reports that beyond the UK, based on current levels, global meat consumption is set to double by 2050, mostly in developing countries, due to rising incomes and urbanisation.

PRODUCTION: HOW WE'LL BE PRODUCING IT

There is a strong link between agricultural and horticultural productivity and investment and the uptake of innovation. Given the need for UK farming to address the so called "productivity challenge", it is right that we look to the future to gain a better understanding of the technological possibilities that will be available. It is in the interests of farm businesses to be early adopters of new tools and practices like those outlined here to enable them to be more competitive and meet the needs of shoppers. It is clear that new management practices, policies and knowledge exchange will be needed, as well as innovative products, to achieve this.



PICKING THE RIGHT TIME TO HARVEST

The Wilkin family started farming in Tiptree, Essex in the late 1700s. Their first batch of strawberry conserve was produced in June 1885 and was sent to Australia by a merchant. The company now exports to over 60 different countries and is proud to have held a continuous Royal Warrant for over a century.



Wilkin and Sons' Farms manager Andrey Ivanov is responsible for growing not only strawberries but also raspberries, Victoria plums, greengages, damsons, quinces, medlars, and mulberries. The jam is made by a factory next to the farm. Mr Ivanov has been working with Dr Vishnu Mohan, a computer science and engineering lecturer at the University of Essex, to develop a prototype robot to pick strawberries.

"We have had a relationship with the university for some years and we are always keen to work with and encourage new developments.

"The researchers at the university, like many across the world, are trying to develop a robotic piece of equipment that will be capable of identifying when a strawberry is ready to be picked then make a decision and pick the fruit by snapping the stem without damaging or touching the actual berry to avoid bruising," Mr Ivanov said.

Dr Mohan's work focuses on developing technology that can identify strawberries at the correct stage of ripeness.

"The challenge is that no two berries are the same - they come in different shapes, sizes, order of ripeness and many are hidden in the foliage," he explained. "Also, the environment keeps changing constantly - sunny, windy, rainy - in contrast to a typical industrial environment. Hence, dextrous manipulation in unstructured environments is a big challenge for robotics today."

The technology is still in its relative infancy, with trials carried out at the University of Essex last summer through a collaboration where Tiptree provided trays of growing strawberries. Mr Ivanov believes that the biggest challenge facing the robots is providing an artificial intelligence that can match the skills of trained human workers.

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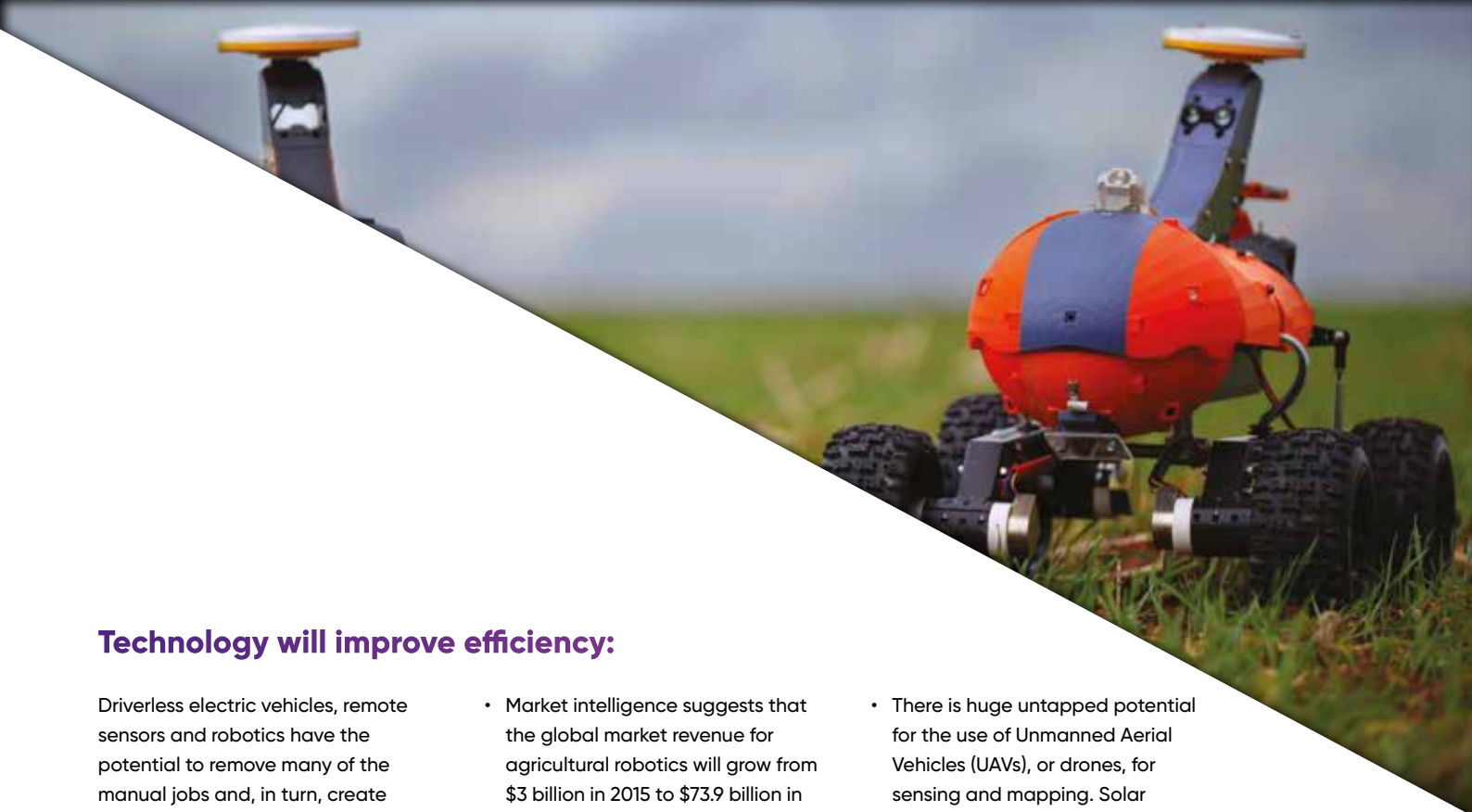
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"It will be very difficult for a robotic machine to replicate the speed, the expert eye, and the judgement of an experienced picker. We have adopted various innovative systems on the farm and it will be interesting to see if the robotic systems can be developed to provide additional picking skills for our strawberry harvest."

When asked if he thought that robots would be widely adopted by 2040, Mr Ivanov answered that this would depend largely on their economic viability.

"Twenty years ago we were growing strawberries on the ground in open fields that were subject to slugs and bugs and were very difficult to pick. We didn't imagine that today all our strawberries would be grown on table tops.

"Therefore forecasting the development of robotics is a challenge. Once cost-effective and efficient robots have been developed for use on fruit farms they may be used on a wider scale in the UK and overseas. Interesting times ahead."



Technology will improve efficiency:

Driverless electric vehicles, remote sensors and robotics have the potential to remove many of the manual jobs and, in turn, create greater precision and efficiency. Opportunities will exist across all sectors, from robotic fruit pickers and precision application of arable crop inputs like fertilisers to the real time monitoring and management of livestock.

- Nanosensors, which the World Economic Forum named as one of the top ten emerging technologies of 2016⁽²²⁾, will be able to collect an array of information from all parts of the farm, such as soil data and water status. Sensors linked to smart applications will be able to send out alerts and reduce daily routine jobs such as checking fuel levels and temperatures. The automotive industry is already using the 'internet of things'⁽²³⁾ to capture real-time information about how vehicles are being driven. Adapting these technological principles for agriculture is entirely realistic for the near future.
- Smaller and lighter driverless tractors and other farm machinery will remove the traditional tramlines of today and help reduce soil compaction. 24/7 operations will be possible, and fears about the countryside being blighted by noise and light pollution at night will be allayed through night vision and quiet electric engines.
- Market intelligence suggests that the global market revenue for agricultural robotics will grow from \$3 billion in 2015 to \$73.9 billion in 2024 alone⁽²⁴⁾. For crops, activities such as establishment, crop care, selective harvesting and crop scouting have all been identified as areas where robotics will make their greatest impact and can be scaled up or down according to field size, according to experts at Harper Adams University⁽²⁵⁾. However, robotics will have impact beyond just the crop sector and will have a growing role for livestock in, for example, milking, general livestock feeding, and even abattoirs.
- Quantum technologies could offer exciting game-changing opportunities for the future across all industries, and could transform the speed and capability of precision agriculture in every way. Quantum sensing and measurement would allow the mapping of invisible underground features, including different soil types and water resources, through the detection of minute differences in gravity. Quantum technology could add superior capability in sensing, navigation and measurement, and take computing and simulation beyond the constraints of binary and into another dimension – potentially transforming the speed and capability of precision agriculture in every way⁽²⁶⁾.
- There is huge untapped potential for the use of Unmanned Aerial Vehicles (UAVs), or drones, for sensing and mapping. Solar powered drones capable of staying airborne for days and capturing real-time information on pests and weather are being developed. Used in combination with hyperspectral imaging sensors (i.e. sensors capable of looking at multiple spectra of light in closely spaced bandwidths), they could be used to detect the early onset of disease and stress. They could even be used for the remote collection of ecosystem information – potentially helping with the monitoring and evaluation of future environmental schemes.
- The routine use of intelligent ear tags with built-in sensors by the livestock sector will allow earlier warning of any potential health issues as well as real-time monitoring of weight and fertility. Research published in Science Direct highlights how sensors may also be used to remotely manage grazing and act like virtual electric fences⁽²⁷⁾ to reduce overgrazing of certain areas or avoid sensitive soils and watercourses.
- The adoption of new technology will also help agriculture reduce its environmental burden through the ability to carry out operations more precisely and with less resources, further reducing its impact on the natural environment.



SMALL ROBOTS – BIG PLANS

The Small Robot Company is developing three robots – Tom, Dick and Harry – to provide autonomous crop care on a plant-by-plant basis.

Founder Sam Watson-Jones explains: “These small electrically-powered robots are designed to be kinder to soil and the environment, avoiding the use of heavy machinery and techniques such as blanket spraying.

“We have worked with Andersons farm consultants to develop a financial model for our robotics service, using my family’s farm in Shropshire as a case study, which anticipates a 40% increase in profit and 60% cut in costs, achieved by labour and fuel savings.

“Yield gains of around one tonne per hectare could be achieved, using artificial intelligence to calculate optimum seed placement.”

The company was launched in November 2017 after customer research among more than 70 farmers to develop the concept in line with their needs. Joe Allnutt, who rejoices in the job title of Head of Robot Awesomeness, was recruited to work on robot prototype development in order to prove the concept, building the first Tom monitoring prototype for field trials commencing in February 2018.

Mr Watson-Jones explains: “This prototype embodies the core technology needed for our farmbot family, including autonomy, geolocation, obstacle avoidance, navigation and the ability to accurately position objects on a map within two centimetres, using bespoke algorithms to finetune the GPS location data.”

Data from Tom is relayed to Wilma, an artificial intelligence ‘nervous system’. “Wilma will draw upon a comprehensive big data crop model for her decision-making,” Mr Watson-Jones said. “Taking data gathered by Tom, Wilma can see every blade of emerging wheat, bumblebee nest, and wormhole. She will then analyse this data to determine what remedial action is required.

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By 2030, the digitisation of farming will transform best practice and farm management

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“Wilma has been trained with the data gathered from phase one of field trials in 2018 and can already recognise wheat from ‘non-wheat’ plants. Next will be weed recognition, and delivery of a weed map. Directed by Wilma, farmbots will only feed or spray the plants that need it, giving them the perfect level of nutrients and support and cutting chemicals and emissions by up to 95%.”

Initial field trials involved 20 farms, including the National Trust’s Wimpole Farm and Waitrose’s Leckford Estate, but a task for 2019 will be to recruit a further 100 farmers for commercial trials.

Based on farmer feedback so far, development of the weeding robot, called Dick, as a field-ready product is the company’s goal for 2019.

Future developments include Harry, which will punch-plant seeds at a uniform depth, with minimal soil disturbance. It will be able to accurately record exactly where it has placed individual seeds, and feed this data back to Wilma, to produce a per-plant crop map.

To overcome farmers’ reluctance to invest in new technology, the Small Robot Company plans to offer a contract service for robot farming, with data relayed to regional centres for processing and action.

The company has raised £1.2 million via Crowdcube equity crowdfunding, reaching its initial target of £500,000 within minutes of its launch thanks largely to support from the farming community.

Mr Watson-Jones suggests that the technology will be commercialised within three to five years and mainstream within ten.

“By 2030, the digitisation of farming will transform best practice and farm management. Younger farmers in particular are very receptive to the idea of robotics – for them, it’s a question not of if but when.

“We can approach 2019 with enormous confidence that we have a vision for a better future for farming, which the market wants to see becoming a reality. We now look forward to making this happen.”



Nanoencapsulation could change the food we eat:

The use of nanoencapsulation in the food sector has been flagged as a “game-changer” in scientific research, as published in Food and Bioprocess Technology. This technology could generate innovation in characteristics such as texture, taste and other sensory attributes. For example, it could allow flavour to be distributed more evenly through a food product, giving taste and sensation but with minimal product. It could be used to enhance colouring, ease of processing, and provide greater stability during shelf-life, leading to a number of new products⁽²⁸⁾.

A new breed of technology:

The generally held view of the experts interviewed for this report was that the use of biotechnology in food production will be ubiquitous in 20 years. This will be largely delivered through new breeding technologies such as CRISPR (Clustered Regularly Interspaced Short Palindromic Repeat), a simple and powerful type of genome editing which is a more efficient and precise method of manipulating genes than the conventional breeding methods. For example, enhanced immune systems and disease resistance, stress tolerance, improved feed conversion rates and better nutritional content and density will all be common breeding traits. This technology will benefit all sectors, but it is important that lessons are learned from the introduction of classic genetic modification on the need for the correct messaging and language and the importance of consumer acceptability⁽²⁹⁾.

Growth of vertical farming:

Hydroponics, aquaponics and other controlled environment systems will not just be a niche market or a novel urban enterprise. While growing crops undercover and the use of hydroponics is not new, the introduction of vertical stacking and recent advances in LED technology will have expanded the range of crops it is possible to grow in this way. Worldwide predictions indicate the vertical farming industry will have a multi-billion-pound value over the next few years⁽³⁰⁾. Supermarkets are already taking an active interest in how this might fit their business model of the future, specifically because of the potential for saving energy and inputs like fertilisers, reducing waste, while also guaranteeing consistency of quality and supply, and the potential for nutritional enhancement. Leafy salads, some vegetables and fruit will all be widely grown in this way. However, its current high energy consumption limitations will need to have been overcome and certain crops will remain difficult to grow.

The development of 3D printed food:

Emerging technology around the 3D printing of food may see new business pop-ups carrying out micro-fabrication based on new flexible production techniques. Recent innovations in this technology, highlighted by Digital Trends among others, have made it possible to print, cook, and serve food⁽³¹⁾. This can be achieved on a mass scale and, as well as simply producing intricate sculptures out of everyday foodstuff that look good, it will also be used to improve the convenience and the nutritional value of meals. It may also reduce the need for some preservatives and mean less waste as food is produced on demand.



High standards the expectation and the norm:

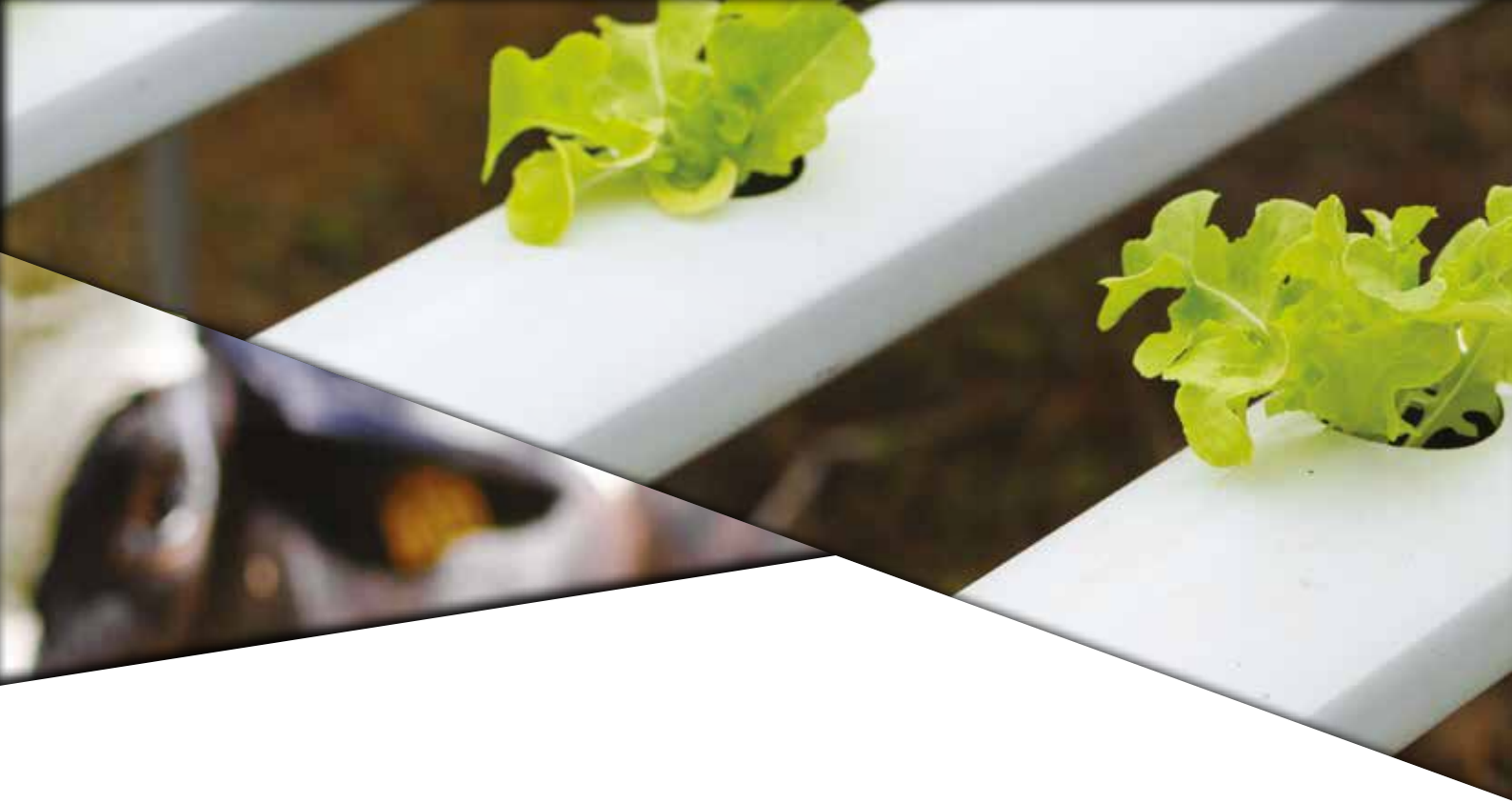
People will continue to value British standards and will expect high environmental, safety and welfare standards as the norm. There has been a growing interest from British consumers over recent years in how their food is produced and who by, as highlighted in research by Which?⁽³²⁾. This is likely to increase over the next two decades, particularly with regard to environmental impact. However, this doesn't always translate into how people make individual product buying choices. Food outlets and retailers will also be making choices on behalf of shoppers, partially driven by legislation, partially by the supply chain recognising the intrinsic need to secure a sustainable supply, and partially as a response to public opinion and lobbying pressure from groups. High welfare standards will no longer be a point of uniqueness for certain retailers and we will see budget retailers move quickly to occupy this space. The Sustainable Development Goals set by the United Nations' 2030 Agenda will further focus political and stakeholder attention on the sustainability of our food system. A Food Sustainability Index has already been developed to attempt to rank performance as a nation and guide policy making. But, despite all this, we should not expect people to want to pay more for their food. Information from IGD shows price, quality and convenience will remain significant drivers of consumer choice⁽³³⁾ and farm businesses will have to work even harder to market their Unique Selling Point and access premium prices in an increasingly crowded market. Provenance and marketing will be extremely important and fiercely competitive and so value-added products will need to stand up to, and stand out from, global competition.

Work will continue to reduce antibiotic use:

The use of antibiotics will remain a particularly emotive area for consumers with a growing market premium for "antibiotic free" meat. The livestock sector has already made huge strides in reducing antibiotic use, with the Responsible Use of Medicines in Agriculture Alliance (RUMA)⁽³⁴⁾ playing a key role, and this work will continue, using a combination of changes in husbandry; the use of smart technologies to help predict, and mitigate against, health challenges and even sniff out disease; genetic innovations and breeding solutions; greater use of vaccines; and better nutrition. Regarding the antibiotics still needed and used, the industry may be left with few options, and mostly older generation products, as the human medicine market necessarily takes priority for the focus of new product development.

Transparency a clear objective:

There will be a high demand for transparency in all aspects of the food chain. Farm businesses will be expected to open their doors to scrutiny at all levels as a matter of course and defend any claims made about their standards of production. Assurance schemes in 20 years' time may still provide much-needed independence, which is valued by shoppers, but they will need to be dynamic and evolving to address shoppers and retailers' needs as well as embedding new technologies like 'blockchain'⁽³⁵⁾ which enables monitoring, data capture and traceability at every point in the food chain.

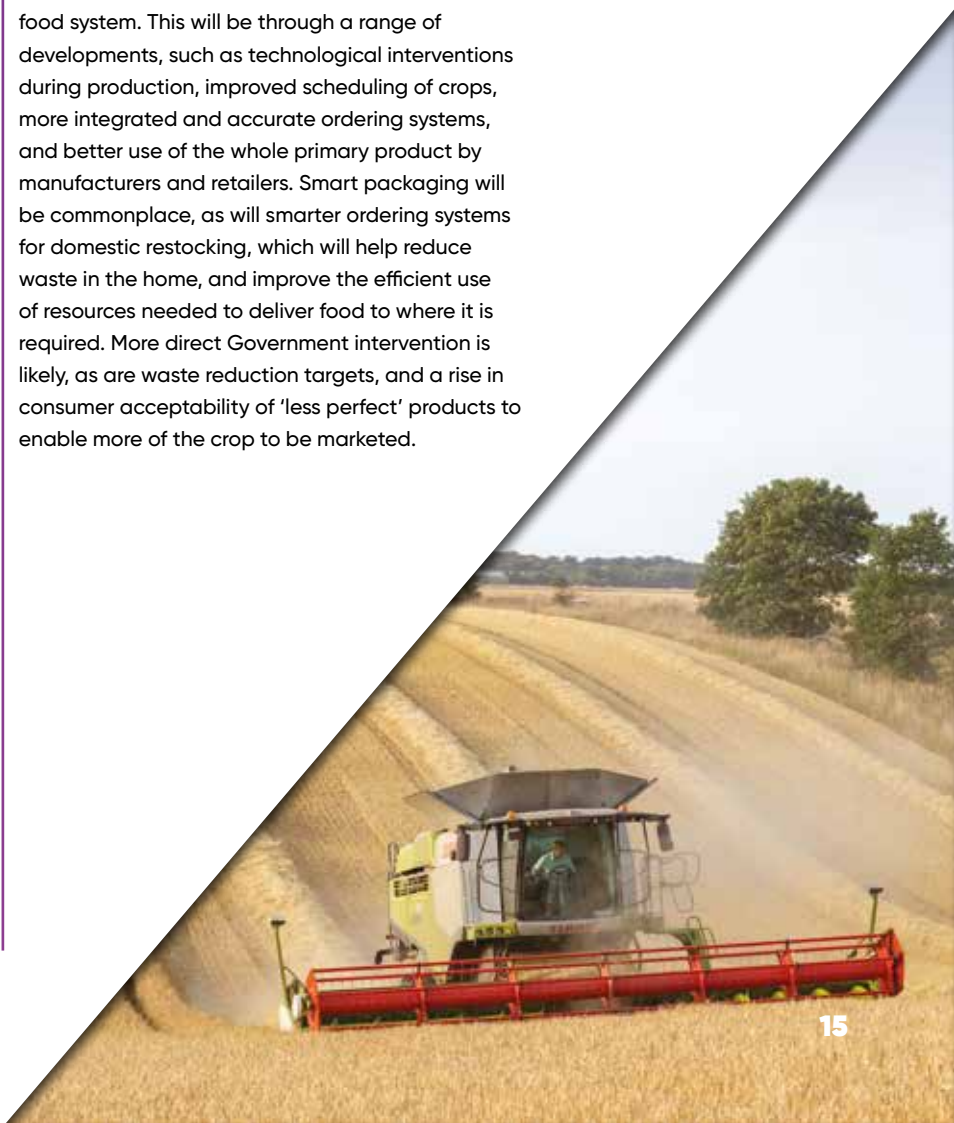


An even more integrated approach to crop management:

Over the next 20 years it will become increasingly challenging for new chemistry alone to provide solutions to pest problems and an even more integrated approach to crop protection will be central to crop management. The need for resistance management using the limited range of pesticides left available to agriculture and horticulture, and the relative low costs of bringing biological control agents to the market, will drive the more widespread use of biological control agents in farming systems. Developments such as biostimulants, which stimulate the crops own defence response to disease, will also be a core tool in Integrated Pest Management (IPM)⁽³⁶⁾, alongside more traditional methods such as combining drilling dates, cover crops and rotations, according to AHDB⁽³⁷⁾. New “game-changing” technologies will also be needed to manage and reverse the spread of resistance, such as in black grass. Developments in 3D printing, like those highlighted in journals including the Beilstein Journal of Organic Chemistry⁽³⁸⁾, may have the potential to change the way the chemicals we still have available are used. Developments in the precision of application technology, using Unmanned Aerial Vehicles or drones to sense and map pests, and then apply a control agent directly and precisely to a weed or affected crop area, will result in use of a significantly smaller amount of any control agent, chemical or biological.

Waste will continue to be reduced:

Waste will be reduced in all areas of the food system. This will be through a range of developments, such as technological interventions during production, improved scheduling of crops, more integrated and accurate ordering systems, and better use of the whole primary product by manufacturers and retailers. Smart packaging will be commonplace, as will smarter ordering systems for domestic restocking, which will help reduce waste in the home, and improve the efficient use of resources needed to deliver food to where it is required. More direct Government intervention is likely, as are waste reduction targets, and a rise in consumer acceptability of ‘less perfect’ products to enable more of the crop to be marketed.



FENCING WITHOUT PHYSICAL BARRIERS

New technology becoming commercially available could offer alternative ways of controlling grazing livestock by keeping stock exactly where they are required using GPS and smartphone app developments.

Investigations into the practicalities of 'virtual fencing' by a team at Scotland's Rural College (SRUC) suggest such technology could provide a way of overcoming the practical, cost and maintenance downsides of conventional or electric fences.

"Over the past 20 years a lot of research has been undertaken into virtual fencing and, while in the UK there is still some work to do to suit our farming methods, adoption has begun here and cost-effective commercial systems are already being used in other parts of the world," said Dr Tony Waterhouse, former head of SRUC's Hill and Mountain and Beef Research Centres.

The technology involved is a combination of animal collars, cloud computing and smartphone, tablet or computer-based software, and as the cost of the elements that go into the make-up of these continues to come down, wider adoption becomes more likely.

"Animals are fitted with neck collars incorporating negative electric stimuli capability, a GPS receiver, and a controller linked to cloud computing via a communication module," explained Dr Waterhouse.

"Solar technology has been developed to power these. Once the desired grazing boundary has been 'drawn' on the software, the GPS receiver recognises this, and the collar provides an electrical stimulus when the animal approaches that boundary.

"But there's much more to the capabilities of virtual fencing. While creating external boundaries using such a system may not always be practical due to the potential, for example, for animals or humans to intrude from outside, there's considerable value in using the technology for boundary creation inside large fields. This would allow paddock grazing to be adopted without permanent or electric fencing.

“
Field areas that need to be protected from animals can be virtually-fenced, protecting walkers on footpaths, old monuments, and easily-damaged areas such as rivers and ponds
”

"Similarly, barriers can be created to allow strip grazing, which can be moved from the farm office computer or, via a smartphone or tablet, from anywhere the farmer happens to be. Virtual fencing can also be used to gather animals and hold them in a certain area, eliminating labour, time and stress to them and farm staff.

"As another example, field areas that need to be protected from animals can



be virtually-fenced, protecting walkers on footpaths, old monuments, and easily-damaged areas such as rivers and ponds."

Virtual fencing technology also transfers information on animal location, via the Cloud, to the management software. One benefit is that this allows animal positions to be monitored, Dr Waterhouse said.

"For example, an animal that hasn't moved for some time or appears separated from others can be checked for illness. It also aids livestock security. A farmer can be alerted if animals move beyond the pre-defined boundary."

Globally, there are two commercial systems now available, one developed in Norway for goats and the other in Australia for cattle and being readied for global launches, said Dr Waterhouse.

"UK trials are planned for this summer, and while cost, complexity and headage numbers means use of such systems for sheep management may need more development and cost reduction, at an estimated cost/head of more than £100 for cattle the technology is ready but still expensive. In 20 years' time, there's no reason why it won't be a commonplace method of grazing livestock management."

IMPACT:

WHAT IT MEANS FOR BRITISH FOOD AND FARMING

Agriculture in the UK has been in a constant state of flux and change for centuries in response to the changing needs of society, shifts in policy, and economics. However, developments over the next two decades could escalate change at a more rapid pace than has been seen for several decades. The continuing consolidation of farm businesses; a wave of new and exciting technologies; a generational changeover of the ageing farming population; and the removal of direct support in its current form, will gradually create a transformation of farm businesses over the next 20 years.





Building business acumen:

We will see a drive towards “business management intensification” of the farming industry alongside the intensification of IT and data use. For all the technology a business can invest in, only businesses that can apply it well will thrive. Business acumen and commercial insight will be crucial and the farmers and growers of the future will need to be digitally literate and increasingly professionalised. As part of this, farm enterprises will need to adopt a longer-term view of their business with long-term profitability replacing the “price on the day” mentality.

Understanding financial risk management:

Farm businesses will increasingly need to get involved with, and more importantly understand, financial risk management. With a move towards increasingly liberalised markets, there will be greater demand for risk management tools which target price volatility mitigation as farm businesses are increasingly exposed to global supply and demand pressures, according to research from the RISE Foundation in Brussels⁽³⁹⁾. Futures markets targeting commodities such as dairy, broad-acre crops and potentially livestock have the potential to be increasingly utilised by the agri-food sector to manage volatility across the supply chain. It also requires mandatory price reporting, which is a Government responsibility. In practice this will also require more active involvement from processors, manufacturers and large retailers in hedging market risk on a futures market, in turn enabling these customers to offer farmers fixed prices in the medium term through forward contracts. The teaching of risk management skills will be core.

One business size won't fit all:

We will see an even more diverse and dynamic range of business models emerge. The 2016 Central Association of Agricultural Valuers (CAAV) Survey of annual let land in England and Wales showed there was a “virtual standstill” in land changing hands, which is largely thought to be driven by the current system of area-based entitlements and payments⁽⁴⁰⁾. However, in a post-Brexit world we may find ourselves in a far more fluid situation with arrangements emerging including share farming, contract farming and much greater collaboration (both formal and informal) between farm holdings, and with Government incentives to assist some of these arrangements. These different business structures, many of which already exist, will become more common place and provide opportunities for new entrants who have struggled to get their first step on the farming ladder. Report interviewees generally held the view that, in many cases, there will be a growing disconnect between land management and ownership. Consolidation driven by economies of scale will continue for many, with an increase in the number of larger scale farm holdings and more corporate ownership, although some of this will effectively be invisible in terms of how the countryside appears. With these changes it will be increasingly important for the industry to work hard to dispel myths that big is necessarily bad and that small is necessarily inefficient. Such simplistic comparisons based on size are unhelpful, as research from CPRE shows⁽⁴¹⁾. Similarly, the industry will need to promote the fact that the use of technology and innovation in a farm business is completely compatible with environmentally sustainable farming, regardless of size, as highlighted in a report by Conservative MEP Anthea McIntyre⁽⁴²⁾. Despite the overall trend towards larger farm holdings, smaller and adaptable businesses will still have an important part to play in seeking out and meeting market demand for quality and local produce where provenance commands a premium. However, specialist and premium produce will remain only a relatively small proportion of the food we eat as a nation. As part of this mix there will continue to be a significant number of farm enterprises where primary production is not the main source of income.



The transformative role of data:

The role of data will be transformative, presenting new opportunities for the development of smarter applications, tools and services and creating better real-time management, market intelligence and monitoring. We are currently on the cusp of a new era where we see the true interface of the life sciences and computer sciences which together may liberate the potential of a whole system approach tailored to individual farm businesses, according to the Open Data Institute⁽⁴³⁾ and others interviewed for this report. This will contribute significantly towards addressing the productivity challenge for farm businesses and make smarter optimal use of expensive resources such as energy and water. Platforms will be far more integrated and interoperable and many of the fears around security and data ownership by monopolies will have largely dissipated as a result. Big data will allow the collation of data on a huge scale beyond anything conventional experimentation would allow. Applications of the future will combine this big data with real-time sensors allowing data layers to be overlaid over multiple years to help identify the optimal management interventions for a particular set of circumstances. This kind of work is already being carried out using systems like fieldmargin⁽⁴⁴⁾, an online system which: acts as a hub where everyone working on a farm can chat, and share information and tasks; allows for the recording of field observations and problems on the go; and means farmers can see where their team and machinery are and what they are working on. They will even allow the farmer or grower to identify the point at which the optimal profit margin has been reached. However, simplicity and ease of use will be the key to the success of these applications, so farm businesses will not be dependent on experts to interpret the information they provide.

Changing jobs:

A positive by-product of labour-saving technologies is a safer and cleaner farming industry, which is more attractive to new entrants from more diverse backgrounds and opens up potential new supporting careers around professional advice and technical expertise. We may also see more women attracted to the industry as heavy manual jobs become less dominant. However, changes in job roles are likely to be an inevitable feature of the whole food supply chain resulting in fewer traditional farm workers and potential concerns around unemployment. This, in turn, could exacerbate the existing isolation of farmers and growers and associated existing issues such as depression and mental illness. While technology can improve jobs it is important to remember that labour-saving technology cannot replace the intuition and decision making of the farmer or grower.

Better connection with the public:

There will be increased opportunities for some farms to better connect with the public and capitalise on eco-tourism as travelling abroad becomes more expensive as a result of rising fossil fuels costs as pressure increases globally to reduce greenhouse gas emissions and carbon footprint. Some farm businesses may set themselves up as local community hubs offering meeting places and spaces, energy generation, and office space for other micro rural businesses. Local government grants could be available for farm businesses offering access to well-designed and signposted digitally-guided farm walks as part of the growing health and wellbeing agenda and to increase levels of engagement between the public, food and countryside.

Better exchange of knowledge and skills:

In addition to vertical integration we may also see more horizontal integration of farm holdings, enabling better sharing of knowledge and skills. With the continuing trend for consolidation, the farmer or grower of the future will be much less hands-on, having to buy-in specialist technical advice and expertise where needed. This model of operation is less well suited to smaller holdings because of the associated costs of buying-in expertise. This may drive a degree of horizontal cooperation between farm businesses in order to acquire the necessary range of expertise demanded across a modern successful farm business.



More transparent markets:

Markets will have become more transparent with the introduction of mandatory price reporting and this will aid better risk management. The Agricultural Markets Task Force highlighted transparency as a key recommendation in its 2016 report 'Improving Market Outcomes: enhancing the position of farmers in the supply chain'⁽⁴⁵⁾. The provision of better market data, through the development of futures markets and mandatory price reporting, will also allow greater mobilisation of market-based formula contracts, which link to market price indices as well as cost-of-production. This approach is generally seen by experts interviewed for this report as a logical progression in the UK on current cost-of-production contracts.

A more integrated food chain:

Retailers interviewed for this report indicated that they and processors will increasingly partner with, and invest in, longer-term relationships with preferred producers and share risk more equitably. There will be much greater vertical integration and alignment of the food chain (both formal and informal) and several different models of integration will exist. Securing a trusted domestic supply will be part of the risk management strategy of retailers in an ever more volatile world where long, complex and global supply chains carry inherent risk to continuity and quality of supply, according to research by FERA⁽⁴⁶⁾. Ultimately, thriving farm businesses will be those which have closely aligned their end product to their customer – meeting standards of precision and consistency. Similarly, trends research from independent securities business Shore Capital Markets shows thriving supply chains of the future will be those that are agile and able to quickly adapt to the changeable consumer environment⁽⁴⁷⁾.

Improved soil management:

Positive soil management practices will continue to become more integrated into farm businesses. Anecdotal evidence suggests that soil management practices are already changing at pace, with things like the use of cover crops and/or the re-introduction of livestock providing multiple benefits to soil productivity and resilience at different scales. Well managed and biologically active soils are fundamental to sustainable and profitable farming and in 20 years we should see much better monitoring and analysis. Soils with a good structure, organic matter content, and diverse biology will help improve productivity and resilience to climatic pressures, and reduce the risk of runoff and soil erosion. A pragmatic functioning market to "credit" farmers for carbon storage in soils will also have emerged. This has already been seen by some early adopting parts of the world, such as Australia and California, where market-based approaches to raising soil organic carbon enable farmers to earn carbon credits from soil organic carbon projects like rotational grazing and reduced tillage to help improve degraded land⁽⁴⁸⁾.

OPPORTUNITIES: EXPLORING NEW MARKETS

The agricultural sector manages 71% of land in England to produce high quality, safe and affordable food. In parallel, it also plays an integral part in protecting, maintaining and enhancing the British countryside. The NFU strongly believes that competitive food production is not at odds with successfully managing the environment. A significant proportion of future Government funding for farming will be directed to the demonstrable delivery of public goods, meaning the stability and longevity in our future national schemes for environmental management will be key. However Government-driven environmental schemes will not be the only means by which farming delivers for the environment. For some farmers conservation will become a "crop", as environmental services become more freely traded in business to business transactions.





Getting to net zero:

British agriculture will continue to reduce agricultural production emissions and initiate negative emissions as part of an ambition to ensure farming is making a 'net zero' contribution to climate change. This ambition should not be achieved by exporting food production, but will require a combination of policies and practices focused on three key areas:

- improving farming's productive efficiency (including the health and vitality of animals and plants);
- targeted measures to increase and manage carbon storage on UK farms;
- boosting production of land-based renewable energy, including bioenergy for processes coupled to carbon capture, storage and utilisation, to generate credits for greenhouse gas (GHG) emissions avoided and GHG removal.

The role of renewable energy:

The consensus view of interviewees for this report was that decarbonisation of the economy will be firmly embedded into British culture by 2040. In October 2018 the Intergovernmental Panel on Climate Change⁽⁴⁹⁾ issued a report on the potential impacts of global warming and how we can limit the rise in global temperature to 1.5°C. They concluded that the risks and impacts of 2°C average warming compared with 1.5°C warming justified a much deeper and faster policy response, in terms of technological changes to energy and food production as well as human lifestyle. Many farm businesses will be playing a leading role in renewable energy generation and storage providing a vital diversified income and reducing on-farm energy costs. As a result, the role of the farm business as a provider of energy services (hosting battery storage to manage the electricity network, as well as subsidy-free solar and wind power) will have become even more significant alongside food and plant production.

A new era of diversification:

The loss of direct support as we currently know it will result in a reallocation of capital within the industry and structural change. This will impact on some sectors more than others and success will be driven by market forces, with many farm businesses exposed to increased economic, political and climatic volatility. Successful farm businesses will need to have prepared for, and effectively managed, these risks at all levels to ensure their resilience and long-term sustainability. For some, this will herald a new era of diversification, as highlighted in research by CPRE⁽⁵⁰⁾, cutting out the middleman to maximise margins, or increased specialisation and efficiency driving down production costs to maximise profit. Research from NFU Mutual has shown that one in five farmers plan to diversify post-Brexit to make their businesses sustainable⁽⁵¹⁾. The loss of direct support for farming will inevitably impact on the amount of capital available for investment in, for example, productivity and sustainability enhancing innovation. This only goes to strengthen the importance of an ambitious future productivity programme providing targeted investment, supporting research and development, and incentivising the adoption of technical advances that strengthen resilience within the farming sector⁽⁵²⁾.



Conservation as a crop:

Conservation will become the “crop” for some farming areas known for their iconic landscapes. Some form of Government financial intervention is likely to emerge to support farming in specific iconic and marginal landscapes and sites like the uplands, as highlighted by the RISE Foundation⁽⁵³⁾. However, this will be on a contractual basis in return for the maintenance and delivery of certain pre-agreed public goods including restoration. As a result, in 20 years’ time there will be more reliance in these areas on payment for the delivery of public goods, such as carbon storage and water quality, than on the sale of agricultural products. In addition, some more remote areas of the UK will have engaged in some form of limited and managed rewilding, leading to some greater variety in the landscape in certain places. This will be linked to specific outcomes, such as tree planting to address flooding. However, this will remain a largely peripheral, closely monitored, and experimental activity by larger estates and clusters of farm businesses. Public acceptability will also moderate more extreme plans for rewilding, with public outcry against significant and sudden landscape change and land abandonment on their doorstep. This has already been seen with the significant public backlash to the Oostvaardersplassen, a rewilding project east of Amsterdam in the Netherlands⁽⁵⁴⁾ involving red deer, horses and cattle where thousands of animals starved, trees died and wild bird populations declined.

Farming as an environmental solution:

It was the consensus opinion of those individuals and organisations interviewed for this report that environmental concerns will continue, but the farming industry will be seen as the solution rather than the problem. Environmental NGOs will become even more aligned over their messages, but the industry will have taken ownership of the environment it maintains and enhances and will be presenting itself effectively as the solution to issues. There will be a very good story to tell about the positive environmental work British farmers are doing and farmers will be better at telling their story, with a more united voice working hand in hand with scientists and innovators. Initial steps have already been made on this journey with the publication of the NFU’s ‘United by our environment, our food, our future’ report⁽⁵⁵⁾, which aims to inspire farmers and growers and give them a greater sense of ownership of the issue.

The demand for land

Land use for bioenergy will be a necessity, alongside land for food and for biodiversity and ecosystem services. There will also be increased demand around land for housing, with the boundary between urban and rural becoming increasingly tense.





GOVERNMENT ASKS: WHAT'S NEEDED

Optimism and excitement exist in all parts of the food industry – from field to fork – about the opportunities presented by changes in technology and data use like those outlined in this report. Farming, and the food sector more widely, could be early adopters of many new areas of innovation. The agri-food sector is generally seen as a good place to invest for innovation and technology companies⁽⁵⁶⁾ as it is, quite literally, a growing industry where there is huge global potential to plug productivity gaps, meet customers' increasing demands and evolving tastes, and optimise systems with new emerging solutions.

To be able to take full advantage of future developments it is vital the British farming sector is resilient, productive and profitable. To ensure this there will need to be measures and support in place to enable farming to better handle volatility and to enhance productivity. There will also need to be a greater transfer of knowledge between farmers and an improvement in the level of uptake of research and development technology that can deliver benefits to the industry.

Assuming the farming industry has free and frictionless trade with the EU and other trading partners and the industry's labour needs have been met following Brexit, a number of specific Government policy interventions will also be needed in the coming years.



Among the things Government will need to do are:

Fully embrace a domestic agricultural policy that addresses the fundamental challenges of volatility, productivity and the environment.

Factor in proper transition time to exit the current Common Agricultural Policy framework, with no rushed false starts. Platforms and systems must be fully tried, tested and fit for purpose before roll out.

Actively encourage improvement in market information as a prerequisite to developing market orientated risk management tools in the UK.

Invest in innovation and specifically support farm businesses to address the productivity challenge by providing targeted investment, supporting research and development, and incentivising the adoption of technical advances that strengthen resilience within the farming sector.

Consider intervention to encourage the adoption of open data principles and ensure competition and a rich variety of tools and services are made available to the sector, and that data is not just the domain of a few major players.

Ensure that we have an enabling regulatory regime that is fit for purpose, effectively supporting productive agriculture, production for the domestic market, and trade in agri-food products with overseas markets, while protecting the environment and the public. It will need to be science and evidence led with proportionate, risk-based approaches to encourage innovation and improve competitiveness.

Ensure that any funding for public goods is universally accessible to farm businesses, flexible, practical and with a proportionate level of administration and auditing.

Ensure that rural communities have access to the right technology infrastructure and planning framework to thrive and benefit from new business opportunities and realise their potential for advances in productivity.

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