DIGITAL TRANSFORMATION IN AGRICULTURE

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Background

The U.K.'s agriculture sector plays a vital role in the UK food supply chain, producing around 60% of domestic food consumption, contributing £14[1] billion (0.6%) to UK GDP and £25 billion to food exports. It also provides significant rural employment, employing close to half a million people and supporting the continuation of rural communities, which are often some of the most socially deprived areas of the UK.

As a context for Digital Transformation it is important to recognise that the sector is heavily regulated, often driven by government policies and incentives, for example, via Environmental Land Management Schemes (ELMS) where farmers are paid to deliver environmental benefits. It is also highly regulated with animal welfare laws setting standards for animal husbandry, the control of pesticides, soil and nutrient management; by for instance, limiting fertiliser use near watercourses and preventing soil erosion as well as regulating food safety and hygiene, food assurance schemes (like red tractor) and more recently, ensuring net zero commitments are driving government and funding agencies to pursue carbon friendly farming.

The sector is also unusual in being dominated by just nine supermarkets that control over 90%[2] of the food retail market matched to a very large supply base of over 200k farms. No one doubts that the power in the supply chain resides with the supermarkets who dictate the terms of supply so that *farmers often receive less than 1% of the profit made in the supermarket[3]* reducing farmers to 'price takers'. This has led to cheap food in the UK but has also driven down returns to farmers to a point where investment decisions often become impossible without much longer-term contractual arrangements.

Our recent report examines some of the opportunities and challenges associated with the adoption of digital technology in Agriculture. These were considered at a joint DIGIT Lab and Agri-TechE held in Norwich in December 2024, organised by Professor Gerard Parr (Co-investigator) in DIGIT Lab. The following sections include findings from the workshop alongside dedicated research from the DIGIT Lab team.

Technology Adoption Opportunities

In 2013 the *UK Strategy for Agriculture Technologies* (UK SAT) set out an ambitious goal of making the UK a world leader in agricultural technology, innovation, and sustainability. In the years since that strategy was produced, the sector has attracted significant government investments, such as the Strategy for Agricultural Technologies (£160m over five years), the Agri-Tech Catalyst (£15m), four new Agri-Tech centres, and the Transforming Food Production programme. The potential for international trade is enormous, with major reports estimating the current market size for Agri-Tech products and supporting services at around $20 billion in 2021, with a projection to reach $46 billion by 2030 at a CAGR of 17.3%.

Following on from these initiatives and post Brexit, the Secretary of State for Agriculture commissioned a review of automation in horticulture led by Professor Simon Pearson (2022)[4]. The review identified six key clusters of technologies that could help accelerate the adoption of automation in horticulture, with three of these identified as first-wave technologies, including optimised production systems (such as improvements to infrastructure, canopy architectures, and ergonomics), pack house automation, and field rigs and mechanical systems. These technologies are immediately and widely available for mass adoption.

A further three technologies, that is to say, autonomous selective harvesting brackets (e.g. mobile robotic systems), augmented work (including Artificial Intelligence and collaborative robots), and autonomous crop protection, monitoring, and forecasting (such as robotics sprayers and free counting) are in later stages of development and remain unavailable at scale.

The report concludes with three themes for the way forward: securing a source of labour before the mass adoption of technology becomes feasible, engaging government, industry, and academia to increase and accelerate the mass adoption of technology, while also providing the necessary infrastructure, funding, and support for sectoral revolution.

Building on the review of horticulture, our Norwich workshop identified a number of specific technologies that are likely to be adopted including:

- Precision agriculture such as drones, providing opportunities to optimise input use, increase yield and therefore increase productivity; reducing waste and environmental impact.
- Farm management software, enabling farmers to track crop cycles/livestock and formalise data management.
- Automated machinery, for example, robotics including self-driving tractors, autonomous drones, which will help reduce labour costs (and shortages) and improve consistency in planting, weeding and harvesting.
- Climate and soil monitoring through weather stations and soil centres.
- AI analytics that will help with predicting crop disease yield forecasts and enable much higher personalisation of farming recommendations.

Technology Adoption Challenges

Skills:

A major challenge to the adoption of digital technology continues to be the lack of suitable skills. Areas of high agricultural employment in the UK, for example, Lincolnshire, East Anglia and Devon and Cornwall, tend to have low levels of educational attainment and occupational skill levels. For example, the UK's largest food-producing county, Lincolnshire, ranks in the bottom decile for those in professional and associate professional occupations, while is at the top for those in elementary occupations, such as basic manual labour. Hourly pay is just 85% of the national average (bottom decile) with female full-time workers receiving just 82% of the national average.

The impact of digital technologies will depend on the types of agricultural jobs being considered. Our workshop report highlighted the difference between 'cognitive' and 'dexterous' impacts. For example, a robot can replace relatively simple dexterous activities but not more complex tasks. Furthermore, many robots are designed for a single crop or task (for example, weeding), whereas other tasks, e.g. pruning, selective harvesting or disease detection, require a considerable amount of nuanced judgement. Cognitive tasks such as those involved in decision-making around the farm, for example, crop yields, pest control, irrigation, and planting schedules, are often based on uncertain information and seem suitable for the adoption of AI. A recent paper by Marinoudi et al (2024) considered agriculture's exposure to LLMs capabilities and concluded that around 45% of agricultural tasks have either high or partial exposure to LLMs.

Data and data sharing:

Our Norwich workshop highlighted a number of digital technologies which are working well and effectively including: GPS positioning; yield mapping: farm management software such as Yagro; robotic weeding and the precision application of technologies such as See and Spray from John Deere. However, the workshop attendees outlined a number of challenges, including the importance of 'correct data entry'. There was widespread acknowledgement that much data is still kept in handwritten form with a considerable historical backlog. Where data is transferred to a digital form this is often through such basic systems as Excel.

The major barrier to data sharing was one of trust amongst the various parties. Delegates acknowledge that investing in early-stage technology is always risky. For example, the lack of standards amongst technology providers acts as a significant lock-in and has, for example, led to some of the larger farming businesses building their own solutions. There is a significant portability challenge in extracting data from spreadsheets or proprietary cloud platforms and integrating that with the core dataset that underpins the business.

Delegates were also significantly concerned around who owns the data and the sharing of that data without their consent or receiving any financial return. Added to this, there is the cyber risk of any device which is connected to the Internet. This may not be restricted to relatively low-level 'hacking' but a concerted effort by a state actor could significantly impact UK food supplies.

Impact of climate change:

Climate change acts as both a driver of and a barrier to the adoption of digital technologies. For example, increased variability in weather patterns and attendant water shortages or floods lead directly to disruptions in planting and harvesting; longer growing seasons might allow for new crops or multiple harvests, but they may also bring heat stress and changing pest pressures. Extreme weather events can also lead to infrastructure damage in areas which already have challenges in digital communications.

An arresting example of the impact of UK farming practices in climate change is the use of soy as the primary method for livestock feed. Approximately 60% of these soy imports come from South America, where production is often linked to intensive pesticide use and environmental concerns. These include biodiversity loss, deforestation, and freshwater depletion, with an estimated 143 million metric tons of CO2 equivalent (2006–2017) attributed to deforestation in the Amazon and Cerrado biomes in Brazil[5]. Substantial additional CO2 emissions arise from transportation and processing, both in South America and/or in the UK (Gil, 2020). Using digital technologies to support the development of alternative protein production (e.g. pulses) can help to mitigate this challenge.

Technology solutions exist at farm level to help reduce the impact of climate change, but the most impactful behaviour through which digital solutions can mitigate the impact is likely to be increasing productivity and therefore reducing land use and harmful practices.

Digital solutions around precision agriculture, better long-term weather forecasting, crop modelling, and environmental prediction to manage livestock will help farmers respond better to the challenges of climate change. These innovations around data collection, management and interrogation provide the option to do "more with less" and for the industry to have a lighter environmental footprint.

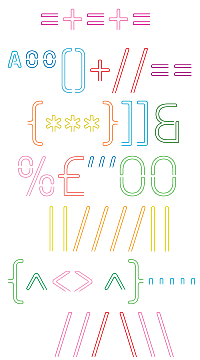
Business models:

One of the often-overlooked barriers to the adoption of technology is that, with over 200,000 farms, there is considerable variation in business models across farm types, sizes, and locations. This provides agricultural technology suppliers with a challenge in scaling their product development and also in customising their products for each type of farm.

Clearly, some technologies have the potential to bring about radical shifts in productivity e.g. automated weeders for vegetable growers, others are likely to be more marginal gains. Large farms are of course, likely to be early adopters, with smaller farms struggling to find the necessary capital. Many small farms remain financially precarious with rising input costs (i.e. labour, fuel, pesticides) making the situation even more challenging.

Future Developments

Agriculture is clearly an area ripe for the adoption of new and emerging digital technologies and this is recognised in the Industrial Strategy[6]. As highlighted throughout the industrial strategy, the problem appears to be not in the development of the technology but rather in the adoption. Agriculture has some very specific challenges that are outlined here, including adapting to climate change, skills shortages and frequent changes to government policy. In addition, the harsh physical and complex regulatory environment alongside a heavily fragmented industry with limited financial room for manoeuvre, making for a highly complex digital transformation challenge.



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