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"Unlocking the potential of technology in UK agriculture"
(AGR001)

After watching the oral evidence session held on Wednesday 13th July, I submit additional evidence for the Committee's consideration. I provide evidence on two questions that Members of the Committee asked:

1. What are the benefits of AI and other precision agricultural technologies?
2. What are the barriers to adoption and how can we help farmers to adopt?

Before I discuss these questions, I would like to respond directly to a point raised in the session.

1. **On the role of Defra in supporting agricultural technology**: a suggestion was made by a witness that food production should be moved out of Defra and into BEIS. It was claimed that Defra was 'not fit for purpose' and needed to be 'sorted out'. It was implied that the environmental bias of Defra restricted its ability to support the rollout of agricultural technology.

   On the latter point of environmental bias. Defra rightly recognises that the future of agriculture in the UK must rely on the best of modern technology alongside traditional practices. There is increasing recognition that whether you favour the language of sustainable intensification or regenerative/agroecological farming that the future of agriculture in the UK needs to adopt an integrated, systems perspective. To meet important environmental targets, such as net zero, reversing biodiversity loss, and tackling water pollution, farmers need to farm sympathetically with the environment. Evidence shows that using less chemical fertiliser in a process of ecological intensification can both maintain yields and protect the environment[1]. Defra's Environmental Land Management Schemes aim to provide public money for public goods, many of these goods being environmental. To achieve higher yields, whilst protecting the environment and supporting farming livelihoods, food production and the environment must not be siloed. Removing the environment from agricultural planning could lead to further intensification of agriculture, which threatens the ecological support systems that crops and livestock need (e.g. soil, climate). Defra must maintain its remit on food production and the environment. Furthermore, agricultural technology, if used in the right way, is essential to sustainable farming. As discussed later, new technologies, such as small robots and other precision equipment, can play a key role in transitioning to regenerative farming systems in which the environment is placed at the heart of integrated farm management.

   Defra is also extensively supporting the adoption of agricultural technology and therefore cannot be described as 'not fit for purpose' in this area. I have critiqued Defra's approaches in the past on this subject and note that policies are rarely, if ever,

[1] MacLaren et al. (2022). https://www.nature.com/articles/s41893-022-00911-x

perfect. However, the range of policy interventions being taken to support agricultural technology is significant. Firstly, Defra has clearly taken a pro-innovation standpoint and is undertaking a number of interventions to enable adoption of agricultural technology: from changing regulation to allow gene editing and conducting an automation review to explore how regulations can support a transition towards automated agriculture. Secondly, there is grant support for farmers to adopt technology; the Farming Equipment and Technology Fund and the Farming Transformation Fund provides grants to farmers to support the adoption of precision technologies with these schemes currently being evaluated. Defra continues to work with Innovate UK to support R+D by farmers, research institutions, and industry through various schemes: Research Starter (28-56k), Feasibility Studies (200-500k), Small and Large R+D partnerships (1-3 million and 3-5 million) and Farming Futures R+D. Defra is aiming to bring forward a plan to 'Accelerate Adoption' of technology. Thirdly, Defra is supporting farmers to make the transition towards agricultural futures by investing in business support delivered through the Future Farming Resilience Fund. These schemes signal strong support from Defra for agricultural technology.

2. Before turning to the two questions raised above, if the Committee wishes to explore adoption challenges for agricultural technology in the future, I would recommend speaking to social scientists, economists, and practitioners who address this subject. These could include Dr Kate Pressland (Centre for Effective Innovation in Agriculture [which explores whether R+D into agricultural innovation makes an impact for farmers on the ground]), Dr Lisa Morgans (Innovation for Agriculture), Professor Tom Macmillan (RAU) Professor James Lowenberg-DeBoer (Harper Adams) and Helen Aldis (Innovative Farmers). I would also be happy to speak to the Committee.

Benefits of AI and agricultural technology

3. There is an extensive literature on the promises of new agricultural technologies, such as Artificial Intelligence, as well as older precision technologies for which more evaluation data exists. The literature asks us to move beyond the 'promises of precision'[2] to explore whether benefits are realised in practice. Crucially, research asks us to investigate *who* the benefits go to, whether these are *equally* shared by different types of farmers, as well as who *loses* from technological change[3].

4. Benefits offered by precision agricultural technology include[4]:

- Increasing yields.
- Reducing inputs, such as chemicals, through precision spraying and weeding and variable rate fertiliser application.
- Reducing emissions if new technologies are powered by renewable energy.
- Increasing transparency in the supply chain.

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[2] Kuch et al. (2020). https://www.tandfonline.com/doi/abs/10.1080/01442872.2020.1724384
[3] Chivers and Rose (2020). https://theconversation.com/the-fourth-agricultural-revolution-is-coming-but-who-will-really-benefit-145810
[4] Rose et al. (2021). https://www.nature.com/articles/s43016-021-00287-9

- Attracting a younger, skilled workforce to a sector in which the average age of a farmer is 59.
- Improving lifestyles by freeing up farmer time (e.g. milking robots have generally been found to improve farmer lifestyles, notwithstanding some concerns over stress caused by 24/7 alerts and too much data).
- Reducing the drudgery and repetitive stress/danger caused by manual farm tasks.
- Addressing labour shortages, which are severe in the UK, particularly in the high value crop sector (e.g. top fruit, soft fruit, field veg).
- Improving animal welfare by allowing individual animals to be monitored 24/7[5].
- Potentially fostering a move to agroecological systems if technologies such as small robots can work within strip cropping or agroforestry systems.

5. It is important to note, however, that for all the promises above, there are potential negative consequences and these might fall disproportionately on farmers with less social capital, power, and adaptive capacity. These include[4]:

- New and different health and safety challenges caused by autonomous technologies.
- The loss of jobs for some in the agricultural sector unless they are supported in developing new skills for a more digitalised world.
- The loss of farmer autonomy as technology companies collect and control data. There is concern over technological lock-in where farmers are reliant on companies for upgrades and repair.
- Potentially fostering more industrialised intensive agriculture (e.g. large monoculture systems or large herd sizes), which could damage the environment.
- Unsustainable sourcing of materials to build new agricultural technologies (life cycle assessments are needed to interrogate environmental claims made).
- Lack of capacity for some farmers to invest in and use new technologies, which can lead some to be ‘left behind’.

6. Agricultural technology can, therefore, be a double-edged sword. Whilst precision technologies offer many promises, it is important to ensure that they are developed responsibly. This requires an anticipation of consequences, both good and bad, and inclusive planning, listening to the views of a range of farming stakeholders (including different types of farmers).

Barriers to adoption

7. Research on the adoption of technology by farmers suggests that it is usually a slow process, although not always[6]. I provide a separate paragraph on four useful studies for the attention of the Committee.

[5] Schillings *et al.* (2021) https://www.frontiersin.org/articles/10.3389/fanim.2021.639678/full
[6] Lowenberg-deBoer and Erickson (2019).
https://acsess.onlinelibrary.wiley.com/doi/full/10.2134/agronj2018.12.0779

8. A review by Da Silveira *et al.* (2021)[7] looked at 50 articles on precision agriculture adoption and generated a list of 25 factors influencing the decision to adopt. The top factors included:

- **Interoperability:** technologies working with other technologies on the farm. This is a major problem as technologies made by different companies do not always talk to one another.
- **Reliability**: technology doing what it says on the tin.
- **Ease of use**: technology being easy to use for the farmer.
- **Infrastructure enables use**: technology is able to work with broadband or phone connectivity and other existing or easily upgradeable farm infrastructure.
- **Business models support scaling**: technologies can be difficult to scale.
- **Skills of the farmer enables use:** low digital skills can prevent use.
- **Information exchange and support available to the farmer**: if farmers do not receive accessible advisory support, adoption can be low.

9. The 'balanced readiness level assessment' framework by Vik *et al.* (2021)[8] is a useful tool through which to judge the readiness of agri-tech in any given place. The authors argue that five components need to be in place before adoption and scaling:
    - **Technology readiness** – the technology performs well and is reliable. The state of readiness of e.g. agricultural robotics is mixed. For some farm operations, e.g. robotic milking or UVC disease treatment of soft fruit, the technology is technically ready. For other farm operations, e.g. fruit picking, the technology is not ready for scaling.
    - **Market readiness level** – there is demand for the technology and there are sustainable business models to support scaling.
    - **Regulatory readiness level** – regulations allow use of the safe and sustainable use of the technology. We have made some recent progress in the UK on developing codes of practice/standards for the use of field robotics, for example. Harper Adams/Centre for Effective Innovation in Agriculture are leading on this. This paper shows how regulations can stand in the way of scaling[9].
    - **Acceptance readiness level** – users are ready and able to use the technology. Farmer readiness is affected by skills, connectivity, finances, advice, trust.
    - **Organizational readiness level** – new technologies are compatible with existing technologies and workflows (interoperability).

New technologies require more than simple technical readiness – they need to be scaled (requires investment), work within the regulatory environment (a challenge for new technologies for which regulations were not designed), there needs to be demand and user acceptance (harder for new technologies that require new skills and ways of working), and the right infrastructure. **For many of the technologies discussed at the oral evidence session, the UK is *not* ready for adoption at scale. To be ready requires social, political, and economic incentives, not just more investment in tech.**

[7] da Silveira *et al.* (2021). https://www.sciencedirect.com/science/article/abs/pii/S0168169921004221
[8] Vik et al. (2021). https://www.sciencedirect.com/science/article/pii/S0040162521002869
[9] Lowenberg-deBoer *et al.* (2021). https://onlinelibrary.wiley.com/doi/epdf/10.1002/aepp.13177

10. Rose et al. (2016)[10]. This study explored adoption factors for farm technology in the UK. It found that the following factors influenced adoption or non-adoption:

Type of factor	Factor	Description
Technology-oriented	Performance/reliability	Technology performs well, improves x, and is reliable
	Ease of use/interoperability	End users can use the technology easily. Easy integration with other technologies on the farm.
	Relevance to user	Technology solves pressing user problems.
	Cost	Technology is not too expensive to buy and/or provides a cost-benefit
	Trust	Technology is transparent and users know how it works
User-centred	Peer recommendation	Fellow users recommend the technology to others
	Habit	Technology matches decision-making habits of the user
	Farmer-adviser compatibility	Technology can be used by farmers and advisers easily
	Age	Younger farmers may be more likely to adopt digital technology
	Skills/education	Farmers with higher education and digital skills adopt tech
	Farm size	Larger farms may be more likely to adopt technology
Innovation environment	Connectedness of AKIS	Support is joined-up and advice is accessible to farmers
	Regulation	Laws, regulations, standards encourage use of technology.
	Infrastructure (e.g. rural connectivity, farm design)	Rural connectivity (e.g. broadband, phone signal) enables use of technology. For autonomous tech, farm infrastructural change is needed (no potholes in roads, places to store and charge robots etc.)
	Marketing	Users know about the technology through targeted marketing

[10] Rose *et al.* (2016). https://www.sciencedirect.com/science/article/pii/S0308521X16305418#f0010

11. Lowenberg-deBoer and Erickson (2019)[6]. This paper provides useful statistics on the rates of adoption of various precision agricultural crop technologies around the world. Some technologies, such as autosteer on tractors, are relatively quickly adopted, although not in all areas. This may be because this technology was cheap, easy to use, easy to integrate with existing equipment, and did not require extensive new skills to use. Other variable rate crop technologies are less well adopted. This paper explores reasons why this might be the case. The key message is that complex, new technologies may take several decades to be scaled.

12. **This analysis shows that a number of policy interventions are needed to help farmers adopt new technology.** This partially involves working with farmers to include skills. But, it requires more than this. Technology developers need to ensure that they are designing relevant, highly performing, and usable tools by co-designing technologies with farmers. Policy-makers need to create an enabling environment for adoption: with grant support, improved rural connectivity, skills provision, regulations which enable adoption, and good advisory support. <u>**The problem of slow adoption will not be solved simply by techno-optimism or by ploughing money into R+D – it is a social and economic issue.**</u>

    In my view, the UK has many of the right jigsaw pieces for agricultural technology adoption, but approaches are not joined up. Unless actions come together – i.e. digital skills are improved which enable farmers to use technology that they can afford and trust, and can use with facilitating regulations and connectivity – failure in one area will prevent progress.

Recommendations to join-up innovation systems

13. **Invest in 'innovation brokers' and co-design solutions**: When deciding on whether to adopt new innovations, farmers rely upon the provision of easily accessible advice. Advisers (e.g. agronomists) can be expensive and some farmers cannot access such advice because of financial pressures. Solutions should be co-designed with farmers. Defra are keen to promote farmer-led innovation. Government should fund a network of innovation brokers or consider further expanding support through the Future Farming Resilience Fund. <u>Ultimately, we need a mindset shift from 'how can we get farmers to adopt our tech?' to 'how can we develop solutions that farmers will use?'</u>

14. **Fund more applied research and trans-disciplinary research**: 'farm management research' looking at decision-making at or beyond the farm gate is the poor cousin of crop and livestock science, even though understanding farm decisions (e.g. economic, social, cultural factors) is paramount to innovation adoption. Support efforts to provide scalable evidence of the value of innovations (e.g. Evidence for Farming initiative).

15. **Close the digital divide and invest in rural digital infrastructure**.

16. **Continue economic and other incentives** (subsidies, tax breaks, information disclosure, public participation in innovation projects) to stimulate adoption and

overcome some financial and other barriers which prevent farmers from investing in new innovations (even in some cases from buying a computer!).

17. **Alternative incentives** (e.g. information disclosure, supporting public participation in innovation projects) may also be needed to address barriers to innovation stemming from lack of trust, risk perceptions, general attitude etc..

18. **Support knowledge exchange activities and reduce fragmentation** that bring together farmers with their peers and technologists and researchers with farmers to improve user-centred design of innovation. Good initiatives include Innovative Farmers and Agri-TechE etc. Compared to international partners (e.g. Ireland), we have a poorly co-ordinated farming advisory system[11]. Push to reduce fragmentation in the knowledge landscape to enable farmers to easily access advice. Currently, we have a competitive splintered system, which is inefficient when there is already considerable knowledge within the community. Knowledge exchange is not just about sharing the latest tech, but making foundational improvements in knowledge that can have substantial, easily implementable benefits e.g. rise of regenerative agriculture. Technological innovation should supplement and bolster excellent practice not seek to replace it.

19. **Further support TIAH** and others in the sector to co-ordinate digital skills provision to farmers and rural communities.

20. **Support efforts to join up the research landscape** which is being led by the Agricultural Universities Council with help from the Centre for Effective Innovation in Agriculture.

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[11] Prager and Thomson. https://www.hutton.ac.uk/sites/default/files/files/AKIS%20in%20the%20UK_flyer.pdf