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Briefing 4617

Innovation and technology in agriculture and alternative foods

Summary

Agricultural innovation is the process whereby individuals or organisations bring new or existing products, processes or ways of organisation into use. Agricultural innovation can increase effectiveness, competitiveness, resilience to shocks or environmental sustainability of food systems. This in turn contributes to food security and nutrition, economic development or sustainable natural resource management.

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Overview

Shocks such as pandemics, conflict and extreme weather events due to climate change may become the new normal in a global food system of 600 million food producers and 8 billion consumers living in degrading environments.[1]

Agriculture also features prominently in debates about the pressures facing the environment because of its broad impacts,[2],[3],[4],[5],[6],[7] such as the GHG emissions associated with

livestock production.[8],[9],[10],[11],[12],[13] As a result, there is an increasing policy focus on companies reporting detailed, quantitative information on environmental impacts to access markets such as the EU (PN 702).[14]

Given the need to respond to these challenges, contributors to the horizon scan identified innovation & technology in agriculture (PN 589) and alternative foods (PN 499) as being of relevance to parliament over the next 5 years. The UN Food and Agriculture Organization (FAO) suggest innovation is one of 18 key drivers of the change in the agrifood system if persistent food insecurity, resource degradation and unsustainable economic activities are to be addressed.[15],[16]

Agricultural innovation is the process whereby individuals or organisations bring new or existing products, processes or ways of organisation into use. Agricultural innovation can increase effectiveness, competitiveness, resilience to shocks or environmental sustainability of food systems. This in turn contributes to food security and nutrition, economic development or sustainable natural resource management.[17]

In 2020, global agrifood systems emissions were 16 billion tonnes of carbon dioxide equivalent (Gt CO2eq),[18] and accounted for around one-third of total greenhouse gas (GHG) emissions from human activities.[19],[20],[21]

Technologies and innovations in the agrifood system, to transition to net zero emissions, have been identified as a major economic opportunity for high-income countries.[22],[23],[24],[25],[26],[27],[28],[29],[30],[31],[32]

However, finance for agri-food system climate mitigation and adaptation is currently limited.[33],[34] Without public investment some technologies may not be affordable in lower income countries, such as digitalisation in agriculture.[35],[36],[37],[38]

Challenges and opportunities

The UN Environment Programme stated that efforts to deliver sufficient food to a growing world population may risk further biodiversity loss.[39]

However, the World Economic Forum stated that solutions such as regenerative farming may offer an opportunity to balance apparently conflicting objectives.[40] However, there is a lack of agreement on a regulatory or scientific definition of regenerative farming, and its adoption may not lead to changes in approaches.[41],[42]

A ‘food system’ approach might be an alternative, or complementary, policy.[43],[44] This seeks to think about the different parts and processes involved in producing food, including networks of decision-makers, natural processes and human activities. It spans all processes and activities involved in food production, processing, packaging, storage, distribution, consumption, and food loss and waste (PN 702).

The FAO has said that science-based agricultural innovations, such as those highlighted below from the horizon scan, create the opportunity to meet both food security and environmental objectives. However, the FAO warned against exploiting innovations in ways that reinforce and perpetuate inequalities, including market concentration, information asymmetry and excluding small-scale actors and already vulnerable populations, or that contribute to the degradation of natural resources.[15]

Among the challenges presented by climate change is that of increased plant pathogen infection risk (PB 51).[45] While this points to greater use of crop protection to sustain yields, there is pressure to reduce the use of such pesticides (PB 43, CDP 2024/0047).[46]

Agricultural knowledge exchange (the pathway of information from researcher to farmer) is complex and challenging due to the large number of organisations and individuals involved.[47] In addition, gaps in the research hinder the use of smart digital technologies to enhance the environmental sustainability of agriculture.[48]
The horizon scan highlighted possible opportunities arising from exploring novel food production for nutritional, food security, climate mitigation and environmental sustainability reasons. These included:

- insect-based foods, a traditional food source in many countries, insect protein is being incorporated into a range of products for humans, pets and livestock[49],[50][51]
- seaweed-based food, both as traditional recipes and as plant-based alternatives to meat[52]
- cultured ('lab-grown') meat or 'cellular agriculture', the production of animal-sourced foods from cell culture. The UK was the first European country to approve putting lab-grown chicken cells in pet food[53],[54],[55],[56]
- precision fermentation of dairy products, using micro-organisms such as yeasts to produce dairy proteins[57]
- plant-based alternatives, products made from plant proteins such as soya, pea, nuts, oats and mycoproteins that mimic meat, milk and other dairy products.[58] For example, the Harper Adams 'pasture to plate' project is seeking to produce edible proteins and oils directly from pasture grass using novel chemical and biotechnology processes that can be incorporated into meat and dairy alternatives.[59]
- 3-D food printing, edible products prepared via an automated, additive process that layers filaments of resin[60]
- indoor farming, where crops are grown under artificial lighting and often in conjunction with alternative growing media (PN 707)[61][62],[63],[64]

Artificial intelligence (AI) was identified during the horizon scan as a significant area of opportunity.

Studies on AI applications in precision agriculture, soil health monitoring, and crop yield prediction[65] demonstrate the potential for sustainable practices. One example highlighted in the scan was its use to support livestock welfare.[66] Another was around

AI-driven precision irrigation systems.[67] AI can be used in crop and livestock genetic data analysis to preserve genetic diversity and optimise crop breeding.[68]

AI may also be applied to improve the accuracy of food supply and demand forecasting to ensure food security. The World Food Programme is undertaking various projects to explore AI's use in this respect.[69] Somewhat similarly, AI can be used to reduce food waste by optimising food supply chains and reducing waste from farm to consumers.[70]

AI's deployment for the continuous monitoring and management of agroecosystem health was identified as a further opportunity. An example is that of work using AI to analyse sound in ecosystems, known as Ecoacoustics,[71] which can be used as part of soil health diagnostics.[72]

A final opportunity deriving from AI was its role in agricultural data management.[73] There are, however, challenges around the use of AI in agriculture, such as the risk of cyber-attackers causing disruption to commercial farms using AI, by damaging datasets or by shutting down sprayers, autonomous drones, and robotic harvesters,[74] as well as broadband provision in 'hardest to reach' rural areas (CBP 8392).

While AI was the technology identified during the horizon scan as offering the greatest potential to support agriculture, some other technological innovations were also highlighted:

- agro-voltaics, where solar farms are integrated into farming[75]
- effective livestock manure management, reducing the need for inorganic fertiliser (PN 710)[76]
- nitrogen removal and recovery from chicken manure[77]
- improved use of animal byproducts from slaughterhouses[78]
- selective breeding for lower emission livestock[79]

Key uncertainties/unknowns

- The approach that the new government will take to agricultural innovation, including the Farming Innovation Programme,[80] which is part of the wider UK Research and Innovation (UKRI) 'Transforming Food Production' challenge.[81]
- Consumer concern around the health impacts of alternative foods, such as lab-grown meat, which was highlighted by Climate Assembly UK.
- There are several uncertainties related to the regulatory framework affecting agriculture. There is a lack of a targeted strategy for ensuring agriculture remains productive as the climate changes,[82] and uncertainty around specific regulatory areas, such as that governing supervision of crop robots.[83] There is uncertainty about how the expected land use framework will seek to balance demands competing with agriculture.
- The fragile nature of supply chains and related costs of key agricultural inputs have recently been highlighted as key uncertainties (PN 710).[84]
- The impact of human pharmaceuticals in reclaimed wastewater used for agricultural purposes is unknown, such as the potential for anti-microbial resistance emerging.[85],[86],[87],[88],[89]

Key questions for parliament

- How should the UK deliver changes to its agrifood system if the future is not to be characterised by persistent food insecurity, degraded resources and unsustainable economic growth, as the FAO has warned?
- What role should the UK play in helping the global food trade to adapt to climate change impacts?[90]

- How can the benefits of agricultural innovation and research be delivered while managing the risks? What financial, regulatory and governance mechanisms are required?
- What mechanisms are needed to improve knowledge exchange, data and materials between agricultural and industrial research in order to get innovations to market? [91],[92],[93],[94],[95]
- What risks and opportunities arise from the use of AI in UK agriculture and how can the challenges, such as investment in infrastructure and equipment or knowledge exchange and skills, be addressed?

Related documents

- House of Commons Environmental Audit Committee. Environmental change and food. security Second Report of Session 2023–24
- House of Lords Horticultural Sector Committee Report of Session 2022–23. Sowing the seeds: A blooming English horticultural sector
- House of Commons Environment, Food and Rural Affairs Committee. Soil health, First Report of Session 2023–24
- House of Lords Select Committee on Food, Poverty, Health and the Environment. Report of Session 2019–20, Hungry for change: fixing the failures in food
- House of Commons Library, Food security: What is it and how is it measured?
- Measuring sustainable environment-food system interactions, POSTnote 702
- Trends in agriculture, POSTnote 589
- Novel food production, POSTnote 499
- Plant biosecurity in Great Britain, POSTbrief 51
- Pesticides and health, POSTbrief 43
- Commons Library debate pack – Debate on the environmental impact of neonicotinoids and other pesticides
- Future of horticulture, POSTnote 707
- Building broadband and mobile infrastructure, House of Commons Library Research Briefing

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The future of fertiliser use, POSTnote 710

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