Farming the future: Transforming the ownership of food systems research and data

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Dec 2021

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Executive Summary

Food systems account for around a third of global greenhouse gas emissions and are a primary driver of land use change and deforestation.[1],[2] Further, even though sufficient calories are produced worldwide to feed everyone, the inequalities perpetuated by the food system mean that around 800 million people globally are food insecure.[3],[4] These dynamics are reflected by the situation in the UK, where agriculture accounts for around 10 percent of greenhouse gas emissions and represents the main driver of biodiversity loss.[5],[6] Further, only around 55 percent of food consumed in the UK is produced domestically, meaning that the social and environmental impact of much production is offshored.[7] Finally, the COVID-19 pandemic has exacerbated the already worrying levels of food insecurity faced by citizens. Research published in The Lancet found that between April and July of 2020 the share of Britons unable to access healthy or nutritious food rose from 3.2 percent to 16.3 percent.[8]

Meanwhile, food producers themselves face a precarious and uncertain future related to changing subsidy regimes, trade deals and increasingly high costs of inputs. Clearly change is required, a fact recognised by governments, as recent legislation throughout the UK around net zero, environmental targets and agricultural subsidies shows.

However, the exact shape of the agricultural change required over the coming decades is yet to be determined. This report takes this fact as a starting point. In doing so, it highlights three processes integral to any form of food systems change:

1. **Research and Development (R&D)** towards new agricultural methods and technologies
2. **The production, analysis, and ownership of agricultural data**
3. **Agricultural Knowledge and Information Systems (AKIS)** intended to popularise and develop food systems practices.

Policies and approaches towards these aspects of agricultural change today will have significant consequences on the food systems of tomorrow. This report makes this point by exploring two future pathways for agriculture in the UK and worldwide. The first shows how existing patterns of **concentrated ownership** and **corporate power** will drive an agricultural transition that reproduces existing inequalities, and environmental injustice. It demonstrates how narrowly focused R&D, tightly policed intellectual property rights and the enclosure and commodification of agricultural data will further entrench ongoing processes of dispossession, value extraction and fossil-fuel dependence.

The alternative pathway, however, offers the potential for a future in which agricultural change is accompanied by **social change**. This vision takes its inspiration from the principles of the growing movement for agroecology. An agroecological approach promotes farming with nature, rather than a reliance on synthetic inputs. It also calls for a redistribution of power that puts producers and citizens, rather than agri-business, in control of food systems. As such, an agroecological approach compliments growing calls for the democratisation of local economies and the promotion of alternative models of ownership like co-operatives and community land

trusts. Within an agroecological paradigm, R&D, data and knowledge exchange processes take a different form. Rather than relying on centralised corporate research programmes and opaque hoarding of data, collaborative networks of farmer-led research, participatory politics, community knowledge exchange and open, publicly facilitated agricultural data are central. This could help build a food system with economic, social, and environmental benefits to farmers, citizens, and local ecologies. These benefits would derive from shorter supply chains creating jobs in regional food systems, reduced emissions associated with processing and transport, the end of harmful synthetic inputs and the phase out of intensive animal agriculture.

Without significant policy interventions, this pathway to a socially and environmentally just food system based on resilient and diverse regional food systems and short, transparent supply chains will struggle to become a reality. Failure would be tragic given the changes Brexit requires of our food system. Departure from the European Union has created significant disruption but also serves as an opportunity to break away from European agricultural policy. The nations of the United Kingdom are uniquely positioned to forge a novel path that would make them a world leader in agricultural policy making fit for the 21st century. As such, this report offers the following policy recommendations that would facilitate this change:

1 Reorientation of public R&D spending

away from efforts to 'sustainably' intensify farming and towards organic and agroecological farming and alternative food networks.

2 Action on Intellectual Property (IP) rights to

ensure ideas developed to help transform agriculture are shared rather than enclosed.

3 Consultation and legislation on rights to agricultural data

that recognises, as with other sectors involving connected devices, the need to prevent data, knowledge, and power accumulating in the hands of a small number of powerful corporations.

4 Publicly funded, free-to-use agri-environmental benchmarking services

for farmers to ensure that agri-environmental data vital to improving farming systems is put to work for the common good, helping to steer a just transition in agriculture.

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5 A data-driven land use strategy

that pushes for greater transparency in land ownership and subsidy data, using agri-environmental data to help develop planning and policy that promotes agricultural diversity, access to land and resilient regional food systems.

6 Land reform that facilitates agricultural research, extension, and transformation

by taking measures to bring parts of massive land holdings into public hands. This land should be redistributed as county farms, agricultural research centres and community land trusts. Equally, where land is already in public hands, putting it to agricultural use should be incentivised, including in urban or peri-urban areas.

7 Regional delivery bodies for research and extension

that provide institutional capacity to deliver these changes whilst facilitating participatory processes that bring together and support existing networks of farmers, citizens, and third-sector organisations.

8 International investment and advocacy

to ensure the capacity for socially just global agricultural change is possible. This includes working to dismantle and reimagine the existing regime of trade and IP. It is also essential that the UK offers financial and technological support, in line with its historic climate debt, to help communities worldwide adapt to and mitigate climate change through agriculture.

1 Introduction

Contemporary ecological and environmental crises demand transformative food systems change. Although the nature and distribution of these changes is yet to take shape, two distinct visions of a future food system repeatedly emerge as potential outcomes.

The first approach is favoured by international agri-business and many state actors. It is a vision of the future rooted in a faith in the problem-solving ability of market logic and the inevitability of technological change. This vision heralds a future in which the dynamics that shape the current food system are perpetuated. Although methods of food production may change, often justified by discourses of sustainability and food security, the underlying power imbalances, competitiveness and injustices of the food system will remain. Agricultural production will continue to rely on a range of inputs produced using fossil fuels and containing chemicals which impact both biodiversity and public health. Supply chains will remain stacked in favour of international oligopolies, rather than food producers, citizens, and local ecologies. States in the Global North, in particular, continue to safeguard such a future's arrival through intellectual property regimes, global trade agreements and the provision of massive agricultural subsidies. Such change can be understood as transitional rather than transformative.

Another vision of agricultural transformation, however, recognises the need for agricultural change to be accompanied by social change. This is a vision associated with the growing global movement for agroecology and food sovereignty.[9,10] In this future, the scale of the challenge is recognised as sufficient to require a far more transformative approach. Instead of a global agri-food system characterised by competition, consolidation, and dispossession, it calls for an agricultural future rooted in co-operation, diversity and commoning. This approach is not without precedent, taking inspiration from centuries of prefigurative practices, ranging from agricultural co-operatives to common grazing lands and subsidies community eating spaces. Indigenous communities worldwide offer examples of how to produce food in a way that protects and enriches biodiversity.[11] Further, the benefits of such an agroecological transformation are well established. This includes greater social and economic benefits to food producers and communities due to lesser reliance on agricultural inputs and the multiplier effects associated with shorter supply chains such as job creation and community wealth building.[12,13] The environmental and ecological benefits are also significant. Research commissioned by the Food, Farming and Countryside Commission suggests that greenhouse gas emissions from UK agriculture would decrease by 38 percent by 2050 if an agroecological transition is successful.[14] Farming organically without synthetic inputs also strongly relates to improved biodiversity.[15] Finally, given the UK's reliance on food imports, reducing the use of commodities like soya for animal feed by transitioning to pastoral grazing systems and palm oil in processed foods by creating shorter supply chains would diminish the UK's international land use footprint, with significant benefits in reducing deforestation.

Regardless of the differences between these visions, catalysing and delivering any successful agricultural transformation relies on three interlinked processes:

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A **Research and development (R&D)** into ways to produce and process food

B The generation and analysis of agri-environmental **data**

C The development of networks for agricultural extension, education, collaboration, and knowledge dissemination – or **Agricultural Knowledge and Information Systems (AKIS)**

These three processes will take radically different shapes according to what kind of agricultural transformation emerges in the coming years. This is true to the extent that the different paradigms encourage contrasting understandings of what the fundamental pillars of 'research', 'data' and 'extension' even are. This briefing explores these tensions. In doing so, it enters a field of debate increasingly structured by differing approaches to what role, if any, 'technology' should play in agriculture. This briefing looks to nuance these debates through a renewed focus, instead, on the role of **ownership** along the food chain. Whilst this report focuses on specific examples from and potential pathways for the agricultural sector in the United Kingdom many of the tendencies observed are of global relevance.

The first section of this report demonstrates how the existing concentration of power and ownership in the food system leads to a limited horizon of research, the enclosure of agricultural data and a fragmented landscape of knowledge and information sharing. The second section offers an alternative vision for an agricultural transformation facilitated by R&D, open data, and collaborative learning networks. The report concludes with policy recommendations for making this vision a reality.

2 Prolonging The Status Quo: Agricultural Transition

Solving contemporary agricultural problems is often a question of technological development. Yet this narrow framing of change emerges from a nexus of institutions – both public and private - invested in perpetuating the existing power dynamics of the agri-food system. Recognising the concentration of corporate ownership at the heart of the agri-food system is central to understanding the rationale of these institutions and the attendant vision of agricultural transition they propagate.

The 2017 iPES Food report *Too Big to Feed* and the 2018 report *Plate Tech-tonics*by the ETC Group demonstrates the situation clearly. International firms with substantial UK interests like Bayer (agrochemicals), Nutrien (fertilizer), John Deere (agricultural machinery), Cargill (trading and processing), Nestlé (processing) and Walmart (retail) exercise a disproportionate degree of power across the food chain.[16,17] The past and present connections between this concentration of corporate power and social and environmental injustices worldwide are well-established.[18] Fundamental to this fact is the extent to which the food chains have been lengthened and complexified by synthetic agricultural inputs at one end and extensive industrial food production processes at the other. Recent data produced by the Food and Agriculture Organisation shows how the share of emissions from these factors has grown since 1990.[19] Such processes now contribute more to agricultural emissions than land use change. Without radical policy interventions these dynamics will shape future agricultural change via their influence over what sort of research will be prioritised, how agri-environmental data is owned and used and via the services through which farmers and land managers access knowledge.

A Research & Development

The growing concentration of ownership, influence, and capital within a handful of firms narrows the scope of agricultural research. The massive financial resources at the disposal of just a few suppliers of agricultural inputs makes this clear. In 2019 the UK Government spent £365 million of public R&D investment on agriculture.[20] This figure is overshadowed by the annual R&D spend of firms like Corteva (£899 million in 2019), Syngenta (£949 million) and Bayer (£2.125 billion).[21,22,23] A 2011 report by the United States Department of Agriculture found that the largest 4 to 8 global firms in different sectors of the agri-food industry were mobilising around 75 percent of R&D spending between them in their respective sectors.[24] Since then, mergers and acquisitions like Bayer's purchase of Monsanto will have only worsened this

situation.

Much of this corporate research is oriented towards locking in future profitability through articulation with existing product lines.[25] These products are, in turn, associated with specific input-dependent ways of growing food which exacerbate water and air pollution, biodiversity loss and soil degradation. And, although there may be a degree of diversity in the agricultural research sector in the UK – including smaller start-ups, public investment, and some farmer-led operations – much research adheres to the horizons of possibility associated with conventional industrial agriculture. Industry consolidation and its impact on research has been further strengthened by the global regime of intellectual property (IP) rights. The protections afforded by IP encourage companies to enclose and monetise existing innovations, whilst creating barriers of entry to smaller firms.[26]

This narrow research agenda encompasses public money spent on agricultural research. Recent statistics put agriculture as the recipient of just 3 percent of public R&D investment in the UK.[27] Often where public money is spent, it supports industrial agricultural development. For example, publicly available data from UK Research Innovation (UKRI) regarding funding disseminated via research councils shows that, Syngenta - an agri-business firm with a global net income in 2019 of $1.45 billion - has been named as a specific beneficiary of, or collaborator in, at least £40 million worth of public research grant funding since 2007.[28] It also speaks volumes that a controlling share of the previously publicly owned Food and Environment Research Agency (FERA) was sold to outsourcing firm Capita in 2015.[29]

These dynamics are particularly apparent in two sectors of agricultural research and development which are positioned as vital to post-Brexit agricultural success: automation and gene editing. Automation, robotics and, increasingly, artificial intelligence already provide assorted services in British agriculture – from automated milking facilities to GPS-assisted spraying machinery. Yet corporate-led agricultural research towards robotics – as firms like John Deere, one of the UK's largest suppliers of agricultural machinery[30] are prioritising[31] – will serve to reproduce harmful dynamics of the current agricultural system.

A narrow focus on researching and developing capital intensive farming machinery is likely to further raise input costs and farmer debt, worsening the already perilous 'productivity treadmill' which food producers face.[32] In conjunction with existing trends and changes to the subsidy regime in the UK, this could worsen the already shocking levels of land ownership concentration across the UK[33] by driving smaller producers out of business. Further, although some robotics or automation may be geared towards replacing labour (the realities and advantages of which remain to be seen) much emergent technology is intended to help increase yields by supporting input-dependent ways of farming. These come in various forms, from autonomous drones intended to use artificial intelligence to target the spraying of pesticides to ground-based robots which determine when and where to apply fertilizer.

Although these developments are framed as ways to increase efficient usage of inputs and facilitate a transition towards 'sustainable' or 'regenerative' agriculture, these developments will lock in future usage and dependence on inputs produced by the same multinationals whose agenda steers so much research. It is no coincidence that, for example, 'Hands Free Hectare', a notable test farm in Shropshire working on autonomous farming, counts Bayer, the world's largest suppliers of seeds and pesticides, and Yara, a global giant in fertilizer production, among its sponsors.[34] This path dependence is further reinforced by the proprietary conditions to

which agricultural technology reliant on platform software can be subject, as struggles for the 'right to repair' agricultural machinery continue.[35]

Finally, although the already mechanised agricultural sectors of the Global North are making progress in rolling out this research agenda, its impact will be felt even more acutely in the Global South where agriculture remains the basis of billions of livelihoods. These developments follow decades of similar efforts to agglomerate, intensify and mechanise farming concerns in the Global North. Comparisons between these developments and the mechanisation and industrialisation of agriculture in the 20th century are easily made. India offers an example of the potential for continuity in this regard given its role within the Green Revolution and its recent farmer protests. It is also a country where the agricultural sector remains its largest source of livelihoods.[36] Mechanisation and the introduction of biotechnological innovations increased yields of certain Indian crops in the 20th century, yet concentrated land in fewer hands with impacts for dietary diversity, landlessness, and rural employment.[37] Given that 82 percent of India's food producers are, to quote the FAO, 'small and marginal', it is reasonable to expect they will not be well positioned to benefit from robotics and artificial intelligence oriented towards monocultural production of a narrow range of crops in the Global North.[38] Large landowners and international agribusiness and patent owners in the Global North, however, are well positioned to benefit, further fuelling the potential for the land grabs and ongoing wealth extraction through IP enclosure and exports.

This is not to dismiss outright, however, the potential of artificial intelligence, automation, and robotics in farming. Recent research by the Soil Association highlights its potential contribution to an agroecological future.[39] However, the dynamics described above demonstrate the interlinkages between ownership concentration, proprietary regimes, and the expansion of fossil fuel reliant modes of agriculture predicated upon the use of synthetic inputs like fertilisers, pesticides, and herbicides. This is a way of farming which prefigures a specific form of agricultural transformation which would lock in existing structural problems under the guise of 'Agriculture 4.0' and 'sustainable intensification'.

These dynamics link clearly to another emergent agricultural research stream high on the UK government's agenda post-Brexit: gene editing. The UK's departure from the EU has created an opportunity to diverge on European legislation concerning gene editing. This builds on the fact that new gene editing techniques such as CRISPR[40] have led to calls for a different regulatory approach to processes which rely on the existing genetics of species, rather than the insertion of new genetics as is typically associated with 'traditional' genetically modified organisms. Accordingly, following a consultation subject to widespread criticism for its one-sided framing, the UK Government has announced its intentions to relax regulations for gene editing, opening a new avenue of biotechnological research.[41],[42],[43] This has come under fire from environmental charities and campaigns.[44] Further, given the devolved capacity in this area it looks set to prolong existing tensions between administrations regarding the regulatory framework for agri-food.

From the perspective of ownership, research and investment in gene editing looks set to perpetuate long standing issues related, again, to the development and protection of intellectual property rights for seed varieties.[45] The impacts of enforcing seed patent legislation are well documented across the world, ranging from driving the indebtedness associated with farmer suicides in India to aggressive litigation against small farmers in the USA.[46], [47] Prior to this legal enclosure of life forms, farmers were able to save seeds from year to year, selecting

those which coped best with current conditions and using or sharing them as they saw fit. International regulation and domestic legislation now requires farmers to pay royalties for the ongoing use of the protected hybrid seed varieties sold by many large agricultural input suppliers. In the United Kingdom, such seeds are used for major crops including oilseed rape, sugar beet and maize. Payment for using licensed saved seeds is enforced under the Plant Varieties Act 1997.[48] The commercial advantages of this system continue to shape R&D, as significant efforts to develop hybridized wheat for the UK by firms like Bayer demonstrates.[49]

In addition, as work by GRAIN shows, it is small scale farmers across the world and local agricultural diversity which suffer most from this regime.[50] Further, the financial barriers to entry created by the technology required to produce gene-edited crops, in conjunction with this existing legal landscape, suggest this new avenue for R&D will only reproduce and reinforce existing structures of ownership and power in the food system by creating new IP opportunities for agri-business and further deepening farmers reliance on annually purchasing seeds.

B Data

The data generated from agricultural production is diverse, covering issues like soil health, greenhouse gas emissions, yields, animal health and land use or ownership. It is increasingly important to both governmental and private interests.[51] Utilising this data well will be vital to reshaping agriculture in the coming years. Yet public entities and research organisations in the UK are not doing enough to facilitate the transparency and infrastructure required to harness data as the basis for knowledge exchange and policy development. As such, the current dynamics of the agricultural system point to a future in which massive amounts of agricultural data are enclosed and commodified by a small cluster of agri-business interests.

Such processes of corporate data enclosure and commodification are already apparent in the agricultural sector. Firms providing agricultural machinery and services are increasingly benefiting from information gathered across millions of data points as a result of the work of farmers and food producers. This issue is particularly salient for adopters of 'precision agriculture' who have started using technologies like GPS-guided tractors or wearable sensors that measure the need for medicines or feed in livestock.[52] Uptake of such technologies in the UK are mixed across sectors, but as high as 80 percent for farmers growing cereals.[53]

A recent report from GRAIN demonstrates the potential impacts of these developments, highlighting the extent to which the articulation of agricultural technology with cloud-computing is generating data for tech giants to enclose, analyse and sell.[54] Food producers using this service, in turn, come to rely on recommendations for using inputs like pesticides or fertilizer generated by these services. Since 2007 John Deere, the world's largest provider of agricultural machinery and huge collector of agricultural data, has been establishing data-sharing relationships with the world's largest agrochemical giants. These companies have, in turn, been acquiring smaller firms producing technologies that collect such data, such as Yara's acquisition of Adapt-N in 2017.[55]

Beyond agri-business firms, tech giants such as Microsoft, via their FarmBeats digital platform and cloud computing capabilities, are increasingly looking to capitalise on the potential

profitability of such data. Microsoft's move into the sector is unsurprising given Bill Gates' own personal interest in land acquisition and his foundation's embrace of 'climate smart' agriculture.[56],[57] Along such lines, the 'data grab' currently unfolding amongst farming in the Global North is likely to extend to the Global South, opening new frontiers for 'surveillance capitalism' in agriculture.[58]

The growing importance of agricultural data raises questions regarding two future policy making issues in the UK. Firstly, legislative and regulatory efforts to improve farming's environmental outcomes require data. The recent Agriculture Act, for example, will link farmers' income support payments to the provision of public (environmental) goods.[59] Further, the recent Environment Act places a great weight on the role of targets to shape environmental policy and its regulation.[60] Regulation and monitoring of both will require assessment of agricultural data. Food producers may be used to providing state agencies with data on pesticide use, acreage or animal health; this emerging governance regime will create a new frontier of benchmarking and assurance services. The existing concentration of data in the hands of private agri-business and the growing importance of private assurance schemes foreshadows the rise of this sector. Provision and consolidation of such services represents an opportunity to extract value from food producers and their data, despite existing efforts by groups to provide free benchmarking tools to farmers such as the Farm Carbon Toolkit.[61]

The rise of data-extraction and benchmarking also has potential to boost efforts to integrate agriculture into markets for carbon offsetting. The market for carbon sequestration credits via agriculture is already established in the USA, with giant firms like Bayer, Cargill, and Microsoft lining up to profit from its establishment.[62] This is a hair of the dog approach to problems created by marketisation and competition likely to worsen existing pressures on land access and ownership, as suggested, for example by research by Wildlife and Countryside Link and recent examples of large private investment firms buying up agricultural land in Wales for afforestation.[63],[64]

Finally, the current approach to public data collection, analysis and publication across the UK suppresses the possibility of transformative agricultural change. There are a range of open data tools available concerning agriculture and land use in the UK. This includes spatial data via platforms like Magic in England or Scotland's Interactive Crop Maps, as well as regularly produced statistical data from agricultural ministries or levy bodies.[65].[66] Yet much data remains opaque and inaccessible, particularly around pressing issues like land ownership, subsidies, planning and taxation, as campaigners have increasingly highlighted.[67]

Further, knowledge produced using public money, for example, via universities or research institutions is often commodified behind paywalls. The recently opened and publicly funded Agrimetrics Centre for Agricultural Innovation, despite some open data functionality, ensures many services are commodified through a 'marketplace' and a subscription service.[68] A future infrastructure for agricultural exchange requires not just more open data, but also the means to analyse, share and utilise it for educational and extension purposes. Additionally, as is set out below, agri-environmental data must facilitate a more strategic approach to land use and planning within communities. The trajectory of the current agricultural system lacks these facets. Agricultural change based on enclosed big data will only lead to further concentration of power and ownership within the food system.

C Agricultural Knowledge and Information Systems

Future agricultural change also depends upon the role of advisory, extension and educational services. In the UK, the provision of agricultural advice is currently a fragmented mixture of public, semi-public, private and third sector provision. The balance between public and private provision differs across the nations of the UK. Many privatised services in England are publicly funded or subsidised in Wales, Scotland, and Northern Ireland.[69] The diversity of services has advantages given that different food production systems may require differing services. A farmer in Wales, for example, may seek out advice on improving biodiversity from the RSPB or Natural Resources Wales, whilst another may look to a private agronomic consultant for ways to increase yields and productivity in line with their goals.

A fragmented landscape lacks the strategic coherence required to steer a democratic agricultural transformation. The proliferation of services has resulted in siloed thinking which ignores systemic approaches to on-farm change.[70] In England this has been driven by the privatisation and outsourcing of services within the sector. After years of commercialisation, the national Agricultural Development Advisory Service (ADAS) was privatised in 1997.[71] Although public agencies like Natural England or the Rural Payments Agency remain, they are not sufficiently resourced for the scale of the challenge ahead. It is estimated it would take the Environment Agency's current staff 200 years to visit every farm in Britain.[72]

Although farmer-led organisations such as the Nature Friendly Farming Network look to build agricultural knowledge collaboratively, many private consultancies and agronomists also have considerable influence over many farmers, particularly in terms of input-usage or purchasing.[73] Frontier Agriculture, for example, is a large marketing business co-owned by Cargill and Associated British Foods which offers a range of agronomic advisory services that pivot around the sale and use of various synthetic inputs and hybrid seeds.[74] Around one in three farmers seek advice from private advisory services regarding productivity and regulation. [75]

This fragmentation is also reflected along the chain and the "vertical" transfer of knowledge from research to application.[76] Experimental publicly owned and run farms have disappeared, as have many local-authority owned county farms.[77] As discussed above, universities have increasingly looked to private partnerships with agri-business to fund research and extension activities. Further, despite increasing numbers of students looking to study agriculture, existing curricula teach young people how to succeed in a competitive, input-oriented environment into which they will enter.[78]

As with research and data issues, the current system of agricultural advice and extension in the United Kingdom heralds an agricultural transition unable to remodel food production along lines of social and environmental justice. This is not to say, however, a return to a centralised or top-down state-led system focused on productivity like ADAS is required. Existing farmer-led networks and the regional focus of current public systems is a strength. However, devolved-level coordination, regulation, oversight, and a framework of 'mission-orientation' would help shape the agricultural transformation required.

3 An Alternative Vision For Agricultural Transformation

Encouraging the agricultural change necessitated by climate and ecological crises requires a fundamentally different approach to research, data, and knowledge exchange. The situation demands a holistic approach to agricultural transformation that simultaneously creates and reinforces social and institutional change. Changes to farming practices must be supported by research into and promotion of alternative ownership models and the decommodification and regionalisation of local food economies. In proposing this alternative vision, the boundaries between research, data and knowledge exchange are blurred. In order to deliver this change institutional reform is required. This could be provided by the establishment of regionally focused and publicly run delivery bodies which would act as locally accountable centres for domestic agricultural transformation. These bodies could be statutorily empowered by any or each of the devolved nations. Their role is fleshed out below.

Research and development, data and knowledge exchange are vital for this alternative vision given the extent to which conventional agriculture currently feeds people in the UK. Although organic grocery sales increased to around £2.79 billion in 2021, total annual grocery spending is around £200 billion.[79,80] Missteps in UK agricultural transformation could lead to food price spikes and increased dependence on imports produced to lower social and environmental regulations. As such, it is necessary to assert that this is a long game, with research, data, and extension services vital in building a bridge to a future in which agriculture provides greater social and environmental benefits. Recognising this is not equivalent to dismissing the potential of alternative methods of farming to produce sufficient and diverse food for the existing global population. Research by the Food, Farming and Countryside Commission, for example, models a pathway to a future UK food system capable of producing sufficient healthy food whilst reducing emissions and eliminating synthetic pesticides and fertilizers.[81] Such a transition would bring substantial economic, social, and environmental benefits. Economically and socially agroecological transformation would help build resilient regional economies, shorter supply chains, creating good food jobs and linking farming into circuits of local democratic participation, food citizenship and the promotion of healthier, plant-based diets. Environmentally, moving towards agroecological methods, techniques, and systems by reducing input usage, phasing out intensive animal agriculture and shortening supply chains can offer significant benefits in terms of emissions reductions, biodiversity improvements, soil health, air and water pollution.[82, 83, 84, 85, 86]

Finally, an internationalist and anti-imperialist element is an essential component of the vision below. Although increasing domestic food production is important for reducing the UK's

global land footprint, it should not lead to an inward-looking approach or a belief in the possibility of any form of self-sufficiency but rather a more progressive approach to trade, along the lines of the model set out by the Land Workers' Alliance in their report *A Vision for Positive Trade*.[87]

A Research

Public and private agricultural R&D requires drastic reorientation. The potential for alternative food systems has long been promoted by social movements associated with organic, biodynamic and permaculture farming. Yet such approaches remain underutilised in the UK context due to a lack of institutional recognition and funding. Institutional objectives for agricultural research have long been aligned towards intensification, homogeneity, and a narrow definition of productivity. This has come at the expense of recognising the importance of agricultural diversity and regionally specific agricultural approaches. What is needed is a significant reallocation of resources away from research intended to create shareholder value for agri-business and towards research intended to create diverse farming systems that reduce inputs whilst maintaining yields, restoring soil health, and improving biodiversity. Although many farmers and communities are championing such approaches already, resources are required to scale up and scale out these approaches.

Redirected research expenditure should prioritise refining and rolling out methods of agroecological agriculture and horticulture oriented towards producing diverse plant-based food for humans rather than animals. Yet it is not possible to predetermine the exact shape of the research required, which must be developed in conjunction with farmers and communities. However certain approaches to farming and agricultural methods already exist which serve as the foundation for such a research agenda like agroforestry, integrated pest management approaches, no dig horticulture, drip irrigation, organic fertilisation, and intercropping.[88,89]

As is widely encouraged and increasingly valorised by agricultural ministries in the UK, this novel research agenda must include farmers.[90] However, it must also recognise the extent to which land and ownership of food production systems are held in increasingly fewer and fewer hands. Further, for the most part, these hands are male, with 2016 statistics suggesting that around 84 percent of English farm holdings are owned by men.[91] Farming is also one of the least ethnically diverse sectors of UK employment.[92] This necessitates research that does not consider only land-owning farmers as stakeholders and collaborators, but also recognises the contribution of tenant farmers, crofters, agricultural workers, and wider rural communities. Those professionally involved with farming can obviously contribute their expertise to developing research, ensuring its relevance, applicability, and accessibility. However, broader community involvement is necessary to build an agricultural transformation that is democratic, just, and socially sustainable. Indeed, the scope of research should also extend beyond rural communities into urban areas, acknowledging the growing interest in both urban agriculture and establishing connections between urban markets and rural producers via farmers markets and community supported agriculture.

The institutional infrastructure required for this research agenda would include existing actors like farming associations, regulatory agencies, environmental and conservation groups, and local authorities. Yet the establishment of mission-oriented regional delivery bodies would

take responsibility for coordinating, demonstrating, and financing the transition. They could also help establish democratic processes like farming forums, citizens assemblies or sortition. This would allow for the facilitation of regional networks of farmer-led and community-informed research projects and articulation with existing research-oriented bodies like universities and private firms whilst also creating local democratic processes. Regional delivery bodies would also ensure this research agenda would overcome the current "vertical" gap between research and extension services. This approach could also be used to catalyse, incentivise, and shelter research networks which could translate into cooperative forms of agricultural production, processing, and distribution networks. As such this could be a way of creating food chains held in common by farmers, community organisations, social enterprises and anchor institutions like universities and NHS trusts. Work is being done in both of these directions by governments in the UK. For example, the Welsh Government's Co-operation and Supply Chain Development Scheme offers grants to projects which bring farmers together to create a better food system.[93] In Scotland, the Knowledge Transfer and Innovation Fund finances networks for farmer-led training, demonstration, and innovation.[94]

This research agenda would also link research in the 'hard' sciences with more experimental participatory social scientific research that looks to develop and scale resilient, regional, commonly owned supply chains. Recent research by Sustain shows that developing such alternative ways of organising food systems and markets is supported by many farmers.[95] These research programmes could, for example, trial radical and social food systems innovations like a basic income for farmers, free-to-use membership-oriented community kitchens and restaurants, community land trust farming, local currencies for local food purchasing (such as a 'Beetroot Bond') and National Nature Service style farming apprenticeships for young people from socioeconomic backgrounds underrepresented in farming.[96,97, 98,99,100]

However, given the scale of the transformation required existing research and innovation frameworks would have to be adapted rather than abandoned. Firms working on private agricultural research and development would require re-orienting through a combination of taxation and a shifting baseline of regulation. Public and semi-public research agendas would be easier to repurpose, given their reliance on grant funding through bodies like UKRI. The pivot towards agroecological knowledge production also requires the training of a new generation of agronomists, ecologists, technicians, and other experts. This should also be established through targeted public investment channelled to regional bodies capable of democratically establishing the sector's local needs, priorities, and specialisms, in conjunction with regional Centres for Agroecological Research hosted by universities or agricultural colleges. Further, this is not to dismiss all existing research towards, for example, automation or gene editing. However, research and development should be embedded in a framework of assessment and grant-funding conditional upon the social impact of technologies like their affordability, accessibility, input requirements, capacity for shared and common ownership and intellectual property ramifications. As subsidy spending is reoriented towards 'public goods', so too should investment in agricultural research.

Work is being done in these directions by some governments in the UK. For example, the Welsh Government's Co-operation and Supply Chain Development Scheme offers grants to projects which bring farmers together to create a better food system.[101] In Scotland, the Knowledge Transfer and Innovation Fund finances networks for farmer-led training, demonstration, and innovation. Yet the scale of change required goes much beyond these

workstreams. In terms of funding, much could be gained through reorientation and reallocation of existing money. Yet environmental uncertainty and supply chain volatility make increasing spending on domestic agricultural production a strategic choice. For example, reorienting 25 percent of public money spent on developing weaponry ('defence') and the 'exploration and exploitation of the earth' would double the public R&D budget for agriculture.[102] The total sum would increase even further if the current governmental target of 2.4 percent of GDP being spent on R&D by 2027 was boosted to 3.0 percent by 2030 (less than the current level for Austria, Belgium, Japan, or Germany).[103]

There is also a vital international strand to this transformation. The UK's historical economic development relied on imports of food from countries like India which will now feel the harshest effects of climate change. Further, the UK's responsibility for its disproportionately large share of historic emissions must be recognised. Debt cancellation and climate reparations are required.[104,105] Further, wealth transferred should be spent as democratically determined by recipient states in the Global South. The UK should, however, also work to transfer and share suitable agricultural technologies from North to South, to facilitate international networks of agroecological knowledge exchange, participatory learning, and open data. This must be supported by international efforts to transform the legal architecture of international trade and its governance of intellectual property rights which, in its current form, help to preserve wealth extraction, land grabs and rural displacement at the expense of commons-based property systems.[106]

B Data

How agricultural and environmental data is owned, analysed, used, and circulated will be pivotal to ensuring a just and successful agricultural transformation. Current practices of data extraction, enclosure and commodification limit the potential for data to facilitate such a transformation. An alternative vision for creating an agroecological food system requires the use of open and interoperable data across the agri-food chain, as many groups such as GODAN already call for.[107] However, to ensure a food system that prioritises environmental justice, cooperation and common ownership, further steps must be taken beyond this. This is recognised in the recently published National Food Strategy recommendations, which assert the need for a National Food Systems Data Programme.[108] Their recommendations for greater transparency, standardisation and publicly accessible visualisation are necessary and urgent. But data also needs to be steered towards specific ends that will shape a different food system rather than being transparent for its own sake.

Firstly, regional agricultural delivery bodies could take on a role in helping coordinate the public access and use of agricultural data by farmers and the broader research networks discussed above. This would ensure that access to data was not just open, but accessible, operationalizable and tailored to regional needs and concerns. Data would be agglomerated via farmer-led research networks and via publicly managed remote sensing exercises, soil sampling programmes and biodiversity surveys. This would be in addition to the data collected by existing regulatory activities and as part of the conditional dimensions of future agri-environmental subsidies. These programmes would articulate with efforts to develop a publicly funded, open-

access, standardised platform for benchmarking environmental performance on farms, such as calculating carbon sequestration, local biodiversity priorities, soil health and other factors of agricultural production.

Data could also be harnessed to help inform and shape the social aspects required of any agricultural transformation. The possible role of data for reforming land use and ownership is notable in this regard. Developing accountability and transparency in land ownership and usage data could help foster policies oriented towards more democratic land ownership by providing an evidence base for the sort of policies set out in the 2017 report *Land for the Many* commissioned by the Labour Party.[109] In conjunction with the agri-environmental data set out above, this could also help delineate options for land use governance. Following Scotland's lead, Land Use Strategies or Commissions for England, Wales or Northern Ireland could be fed by regionally generated geospatial data, with national level recommendations filtered back through localised institutions. If a balance is to be found between agricultural land use, renewable energy generation, afforestation, and liveability then these data sets will be vital. This strategic gap is widely recognised, including by advisors to the Geospatial Commission and in the recently published National Food Strategy.[110,111] Yet such an approach must not be an exclusively bureaucratic exercise, but rather a starting point for using data to reclaim, redistribute and repurpose land. These frameworks could also have fiscal ramifications, showing where greater resources and investment are required to meet agri-environmental targets and potentially allowing for regionally distributed subsidies that incentivise democratically determined food production and ecological priorities.

However, in this scenario the protection of this data and the establishment of clear rights about data ownership and privacy would also be necessary. Criticism of corporate data grabs cannot be replaced with unfettered governmental access to farmers' data. Farmers and food producers must have legal protection to ensure that others are not profiting from this data generation. However, usage of data generated for the common and public good cannot be considered the exclusive legal property of food producers or land managers. What is required, however, is the establishment and recognition of rights to privacy, commercial and personal, associated with data generation as part of an agricultural transformation. These approaches could be complemented by participation and facilitation of international efforts to protect the data and knowledge of farmers and food producers across the world from enclosure, co-optation and commodification by tech and agri-business giants. Further consultation and strategy are required in this field, however. This is a complex policy area linked to broader questions around the collection and monetisation of data from connected devices across society. Nonetheless, the potential for data to shape a fairer agroecological future is clear.

C Agricultural Knowledge and Information Systems

Agroecological transformation will also rely on a broader understanding of 'data' than the material collected via the above channels. This includes the exchange of practical, experiential, and qualitative data through educational, advisory and extension networks.

Rob Booth

The establishment of regional delivery bodies would look to provide coherence and direction to fragmented local landscapes of advisory and extension services. This would include greater provision of publicly funded in-person agricultural advisory and extension services oriented towards a national transition to more agroecological methods of production. This would be provided by a full-time staff of advisors but could also involve recruiting farmers and agricultural workers as ambassadors, trialists and network coordinators. The agronomic focus would be towards reducing input-dependence, developing whole farm agroecological systems and diversifying production. However, there would also be a social function, with advisors also tasked with developing and articulating farmer-led research networks and trials, assisting with collaborative, and coordinated efforts at, for example, landscape level restoration projects geared towards public goods like natural flood management or restoring peatlands. Efforts to improve take up of data-oriented schemes set out above would also be central. Much diversity in agricultural knowledge around, for example, seed saving, or plant breeding techniques has been replaced by input-dependent, capital-intensive approaches. This must be addressed to create a food system where knowledge is held in common, rather than in siloes.

Further, regional delivery bodies would offer advisory and extension services beyond the farm gate oriented towards popularising and establishing broader changes to food systems. This would include efforts to develop the establishment of purchasing, processing and distribution co-operatives, machinery sharing schemes and the formulation of local networks of dynamic public procurement with small and medium sized food producers. Beyond this advice and extension services could be provided to efforts at food production beyond the farm gate. This would include support for urban and peri-urban agriculture, be this through start-ups, social enterprises, or community organisations. The growing popularity of veg box schemes[112] and urban agriculture[113] are testament to an appetite for these schemes. However, access to expertise will be required to ensure these systems get off the ground and are able to develop into resilient ongoing systems not overly reliant on a few trained experts and the goodwill of volunteers. Extension and advice must also be provided to local authorities. Local government, if empowered and financed to get involved in this sector, could particularly aid this transformation through the provision of public land to food production and the establishment of Public-Community Partnerships that support existing community-led efforts with institutional resources and access to finance.[114]

It is important to note that such work is already being done to produce and share alternative and practical food systems knowledge by non-governmental organisations like the Land Workers' Alliance, the Soil Association, Growing Communities, Agricology, the Nature Friendly Farming Network and Pasture for Life. As Public-Commons Partnerships do at a local level, the purpose of this work would not be to replace these efforts but to provide further institutional resources and support to existing bodies where necessary and the architecture for cooperation and regional outreach.

The capacity for advisory and extension services to link with agroecological research could be bolstered by the consolidation and expansion of publicly run experimental trial farms. This would build on the existing network of county farms to ensure that opportunities are created for agroecological trials, demonstrations and as a hub for local research networks and co-operative organisations. Land is also required for new entrants to the sector looking to farm agroecologically. The current county farm network has served this purpose in the past, but it is shrinking and requires the addition of more farms for research, extension, and new entrants.

As such these objectives could be achieved through three approaches:[115]

1. Land reform aimed at compulsory purchase of land currently offers little in the way of food production or public goods and is owned as part of a large holding. This strategy could be facilitated using the data-led approaches highlighted above in conjunction with more progressive taxation.

2. Public purchasing of farmland where there are no viable succession options for those unable or unwilling to continue farming.

3. Thirdly, by repurposing existing public land, urban or rural, where opportunities exist for agricultural change, for example, some of the 233,000 hectares of public land currently allocated to the Ministry of Defence.[116]

Efforts are also required to revolutionise educational approaches to food systems. This would need to come in many forms, ranging from updating accreditation, impartiality, independence, and licensing requirements for those dispensing agricultural advice on farms to introducing mandatory inclusion of food systems education and practical experience at both primary and secondary school levels of education. Between these two poles, however, is the vital question of reforming how agricultural colleges and universities teach people how food systems should work in practice, and the establishment of apprenticeships, work placement schemes and other means for encouraging a new generation of food producers into the sector keen to be part of the agroecological revolution. These should not be standardised top-down curricula but developed in conjunction with locally determined priorities and networks of farmer research.

Finally, these agricultural knowledge and information systems must extend beyond borders. However, rather than financing developmentalist agronomic approaches that cultivate input dependence and establish export-oriented agricultural programmes that grab and enclose land, efforts should channel the same social and environmental agroecological mission. As such they should be geared towards facilitating international supply chains that encompass more co-operatives and democratic farming methods for produce in the Global South that cannot be produced in Britain. This will not come via imposition of agricultural knowledge, which will be organically rooted in place, but will come via the facilitation of international networks, cooperation on sharing understanding for improving transparent and resilient ways of practising agriculture internationally.

4 Policy Recommendations and Conclusion

The role of research, data, and knowledge exchange systems in the pathways to agricultural change set out above are fundamentally different. The first scenario demonstrates how the current trajectory of technological development will serve to consolidate power amongst those in the food system producing synthetic inputs and machinery and profiting from intellectual property rights and the extraction of agricultural data. The existing dynamics of the food system – intensification, concentration of resources and the displacement of rural populations – will continue unabated despite and due to current practices.

The second scenario, however, offers a pathway to an alternative agricultural system that could develop resilient, restorative ways of feeding communities whilst empowering people – citizens, farmers, and workers – rather than agri-business. It is this kind of transformation, which has a distinctly social dimension, that is required to address the socio-ecological injustice and violence produced by much of the current agri-food system. The eight policy recommendations set out below reassert how this could be achieved in the United Kingdom and abroad.

1 Reorientation of Public R&D Spending

- this would include a reorientation of funding away from research which benefits those who profit from existing modes of extractive agriculture and towards research that looks to develop and refine agroecological farming systems.
- This could come in the form of a specific programme overseen by UKRI and/or relevant ministerial departments in each of the devolved administrations, potentially in collaboration with an Agroecology Development Bank.[117]
- Further, given the need to develop resilient regional food systems in the face of environmental and supply chain uncertainty, the share of the public R&D budget put towards agriculture should increase from 3 percent to 6 percent, via a combination of increases in overall spending and a reallocation of existing funding that facilitates extractive industries or military programmes.
- Efforts should be made to ensure sufficient social return on investment via mapping outcomes and ensuring provisions of public funding was conditional on factors like workers' rights and tax justice, as set out by previous work by Common Wealth.[118]

2 Action on Intellectual Property Rights

- Broader actions would benefit agriculture, such as the creation of IP Commons and an associated governing body, in line with past recommendations by Common Wealth.[119] This would ensure publicly funded research into agriculture creates technologies that are open source, accessible and reworkable according to regional contexts and needs. It could retain IP that aids the public interest and common good in perpetuity.
- There is also scope for measures oriented at large firms who benefit from the enclosure of knowledge, such as the creation of powers to rescind IP rights and transfer them to public management within the institutions of the IP Commons. This could be triggered where, for example, research is being stifled, firms are exploiting workers or paying insufficient taxes.
- An IP Commons oriented institution could also serve as a hub for knowledge sharing and technology transfer with the governments and food producers in the Global South, creating a network for the global exchange of ideas and methods that put shared agricultural goals ahead of corporate profit.
- There is also specific scope for amendments to legislation like the Plant Varieties Act 1997 to begin facilitating commoning of intellectual property, in this instance around seeds, seed sharing and exchange.

3 Consultation and Legislation on Rights to Agricultural Data

- The issue of ensuring fair usage of data generated by connected agricultural devices forms part of a broader question around the use and monetisation of such data across society.[120]
- Developing a comprehensive legal remedy to this issue is beyond the scope of this report, however options should be considered and developed that are oriented not necessarily towards creating proprietary ownership of agricultural data to those who produce it via use of technology. Instead, the focus should be on ensuring openness and the establishment of transparent and uniform rights to access valuable agri-environmental data whilst respecting the privacy of individuals.

4 Publicly Funded, Free-To-Use Agri-Environmental Benchmarking Services

- As part of the development of subsidy regimes based on public money for public goods and efforts to reach net zero in agriculture, agricultural ministries, in collaboration with delivery bodies and executive agencies should develop an open-source, free to use farm benchmarking toolkit.
- This would help create an accessible and standardised platform for calculating farming emissions and impacts, as well as generating data and providing a medium for providing advisory services to farmers about how to reduce input uses, cut costs and transition to agroecological production methods.

5 Data-driven Land Use Strategy

- efforts to accumulate and utilise open agri-environmental and land use data should in turn help inform policy oriented towards optimising land use and making land ownership more equitable.
- This process starts with implementing the recommendations on transparency in the 2017 *Land for the Many* reports, including the publication of open data on all information about land ownership, control, subsidies, and planning.
- This data, along with the accumulated open agri-environmental data discussed above, could eventually contribute towards regionally developed land use frameworks which use data to target subsidies, planning policy and public investment towards increasing agricultural diversity and the provision of public goods like carbon sequestration.

6 Land Reform that Facilitates Agricultural Research, Extension and Transformation

- To develop and disseminate the agricultural practices required to facilitate agroecological change existing publicly owned land could be repurposed (for example from the Ministry of Defence). Private land should also be brought into public ownership where land ownership data shows high levels of ownership concentration and where there are no succession options for existing farmers who are no longer able to farm.
- This could reverse the decline in county farms and instead help create a network of experimental, publicly run facilities which could provide land to new entrants to farming, research programmes intended to trial and roll out agroecological methods and agricultural co-operatives
- These processes could also look to provide land in urban, peri-urban, and rural areas for community buy-out and agricultural operations run as part of a community land trust, community supported agriculture or via public-commons partnerships.[121]

7 Regional Delivery Bodies for Research and Extension

- Institutional reform is necessary for the establishment of regional food supply chains, research networks and knowledge exchange. This could be provided by the establishment of regional delivery bodies oriented towards facilitating the transformation of agricultural research and data usage described above.
- These bodies could act to facilitate agricultural change via coordinating and supporting existing farmer-led networks, community organisations, research efforts and local authority programmes.
- They could also serve a more direct purpose by providing agricultural advice and extension, taking on and leasing out public land as discussed above, supporting the scaling of alternative models of ownership, and developing local data capabilities and convening forms of participatory democracy to help shape the transition.

- Resources would be required to launch and staff these bodies, however synergies could be achieved through institutional support for existing work by public, private and third-sector organisations, as well as by taking on functions of existing national bodies like the Rural Payments Agency.

8 International Investment and Advocacy

- These processes are intended to develop the capacity for regional food systems of empowered producers and citizens to feed communities. However, the fundamental and historically international nature of food provisioning in the UK must not be overlooked. From a perspective of social and environmental justice the impact of British imperial and post-colonial extraction must be recognised and offset by efforts to assist with the movement for food sovereignty across the world.
- The exact shape of these transitions is a question of self-determination for food producers and rural communities worldwide. However, the UK could lead efforts to erode intellectual property enclosures of biological material and facilitate access to technological developments that could facilitate agricultural change, such as organic inputs, remote sensing, and renewable energy generation. Reform of the institutions like the World Trade Organisation which police global trade and have buttressed unfair agri-food systems is also required. As too are efforts to develop international networks of knowledge exchange and international commodity exchange on equal terms.
- Finally, financial support in the form of climate reparations must be offered to those regions where food production is decimated by climate change to which Britain's historical emissions have significantly contributed, via climate reparations, as well as the above measures.

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