British Agriculture: Recovery and transformation after COVID-19

POLICY BRIEF

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Contents

List of abbreviations

AES	Agri-environmental schemes
AONB	Area of Outstanding Natural Beauty
BECCS	Bioenergy crops with carbon capture and storage
CAP	Common Agricultural Policy
CCC	Committee on Climate Change
COGAP	Codes of Good Agricultural Practice
Defra	Department for Environment, Food and Rural Affairs
EA	Environment Agency
ETS	Emissions Trading Scheme
EU	European Union
GDP	Gross Domestic Product
GHG	Greenhouse gas (most notably CO_2, NOX, CH_4)
IUCN	International Union for Conservation of Nature
IPCC	Intergovernmental Panel on Climate Change
MFL	Multifunctional Landscapes
NDCs	Nationally Determined Contributions
R&D	Research and development
SDG	Sustainable Development Goal
SI	Sustainable Intensification
SSSI	Site of Special Scientific Interest
WFD	Water Framework Directive

Summary

Climate change arguably is the defining issue for future generations and necessitates international and local efforts to curtail drastic future scenarios. A major contributor to global greenhouse gas (GHG) emissions is agriculture, including the UK's agri-food sector. In 2013, agriculture contributed an estimated 9% of total national emissions, 79% total nitrous oxide (N_2O) emissions, 48% total methane (CH_4) emission, and 1% total carbon dioxide (CO_2) emissions.[1] The importance of the UK food sector for the country's economy cannot be understated: the food sector provides approximately £111 billion a year to the national economy. The sector accounts for over 13% of national employment and is the UK's largest manufacturing sector.[2] Yet two recent events have rocked the UK: COVID-19 and Brexit, which have both brought to light the long-existing vulnerabilities of the country's agri-food sector. Moreover, the watershed events have offered opportunity for politicians, farmers, and other stakeholders to propose nuanced ideas and policies to finally ameliorate ongoing inefficiencies in the sector.

Efforts to mitigate GHG emissions have come in the form of both international and national agreements and policy. The seminal 2015 Paris Agreement holds countries such as the UK accountable to commitments to adapt and mitigate climate change per the Nationally Determined Contributions (NDCs). Namely, the UK, as a former member of the European Union (EU), has drawn out proposed actions to mitigate GHG emissions and to adapt to climate change to limit global warming to no higher than 1.5 degrees Celsius this century in the intended NDC (INDC).[3] Moreover, the UK passed the 2008 Climate Change Act establishing a nationwide carbon budget, the Committee on Climate Change (CCC), and setting 2050 as the target mitigation year for GHGs.[4] Yet no national policy has directly aimed to address and reduce GHG emissions from the

[1] Department of environment and rural affairs (Defra), 2015. *Agricultural Statistics and Climate Change*. 6th ed. [Accessed 3 July 2020]

[2] Global Food Security, 2017. *Exploring the resilience of the UK food system in a global context*. [Accessed 24 June 2020]

[3] United Nations Framework Convention on Climate Change (UNFCCC), 2015. *The Paris Agreement*. New York, NY. [Accessed 20 June 2020]

[4] UK Government, 2008. *Climate Change Act 2008*. London. [Accessed 10 July 2020]

agricultural sector, particularly emissions directly originating from land use changes.

Hopeful signs that the country has addressed the lack of innovation in the sector is the Agriculture Bill. The bill is intended to replace the archaic and inefficient Common Agriculture Policy introduced in the early 1970s by the EU. Most important is that the proposed bill would prioritise rewarding farmers that deliver the most environmental services such as supporting biodiversity and land restoration. The Government also provides research and analysis in regards to Brexit and implications on food and farming.

Moreover, the UK champions catchment-based approaches to safeguard water resources, air, and soil quality. By enhancing the notion of local nature-based solutions at the catchment scale, the country could better roll out solutions tailored to local communities and develop public-private partnerships. It is absolutely necessary that the sector also invests more funds into R&D of agritech and leveraging these public-private partnerships for revenue streams. Moreover, the government must prioritise land restoration of degraded farmland and even ban practices such as peatland burning to mitigate GHG emissions.

Unless otherwise stated, this brief focuses on England and only mentions Devolved Administrations where necessary.

Background of the policy problem

Why is a transformation of the agricultural sector needed?

There are numerous reasons why UK agriculture needs transformation. The COVID-19 situation highlighted the tenuousness of supply chains, along with the need for greater transparency among stakeholders, as supermarkets and grocery stores struggled to meet sharp increases in demand. The UK Environment, Food and Rural Affairs committee is currently holding inquiries regarding COVID-19 and food supply. Meanwhile, some dairy farmers were forced to dump milk and others to throw out produce they could not sell. Compounding these issues is Brexit, the UK's departure from the EU, which raises questions over the effect on trade balance with European countries, management of food commodities, and regulation of agriculture. This section outlines the issues associated with agricultural activities and the respective problems each pose with regards to climate change, land degradation, water pollution, and trade deficits and global markets.

I. Climate change

According to Michael Bomford of The Post Carbon Institute, agriculture contributes to roughly 20% of global greenhouse gas (GHG) emissions.[5] Agriculture contributes to GHG emissions both directly (e.g., emissions from production) and indirectly (e.g., land-use change for agricultural purposes, fuel costs, transportation costs), with the main GHGs being carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).[6]

The UK-based Committee on Climate Change (CCC)'s January 2020 publication, *Land use: Policies for a Net Zero UK*, examined the direct GHG contributions from the UK agricultural sector and attributed the various agricultural activities as having the following emission contribution breakdown: 10% machinery, 24% soils, 16% waste and manure, and 47% livestock digestive processes (i.e. ruminants). Agricultural

[5] Bomford, M, 2020 [PowerPoint Presentation]. Presented on 3 June 2020.
[6] Food systems and greenhouse gases (FCRN), [online]. [Accessed 20 June 2020]

activities associated with the highest amount of emissions include land use change, livestock, and poor soil management (i.e. excess nitrogen from fertiliser input, flooding, degradation), and different agricultural activities emit different GHG emissions. Activities that require fossil fuel use, such as machinery, fertilizer and pesticide production emit CO_2; CH_4 is typically released from ruminant livestock such as cows and sheep; and N_2O from soil bacteria and nitrogen fertilisers.

II. Land degradation

Management of farmland has implications for the environment and the economy with both spheres often considered to be intertwined. Poor soil practices leading to erosion and salinisation, alongside intensification of farming, have negatively impacted the domestic economy and curtailed agricultural productivity. In the UK, degraded soils result in external costs equivalent to 17% of national GDP, or an estimated cost between £0.9 billion and £1.4 billion per year for England and Wales.[7] Moreover, the rate of soil erosion in the UK is estimated to be between 10 and 100 times higher than it has been prior to intensive farming, with 2.2 million tonnes of soil eroded each year.[8] Eroded soil is not only associated with lower agricultural yields, but decreased ability of the soil to store water and nutrients, which can lead to flooding and water pollution.

Poorly managed wetlands can lead to additional costs to society arising from loss of biodiversity, increased flooding events, contamination of drinking water, damage to farming, and recreational and sporting interests. Peatlands are a particularly important wetland in the UK and have been designated as UK Biodiversity Action Plan priority habitats for their importance in sequestering and storing carbon, biodiversity, and water management. Despite their importance in climate change mitigation, only 1% of England's deep peat have been deemed as being in an undamaged state and much of the UK's peatland is no longer sequestering and storing carbon.[9] Due to poor land use management, the UK's peatlands have become a significant net source of GHGs and represent a risk to global climate, emitting 16 million tonnes of CO_2 each year. The main drivers of peatland degradation are drainage, burning, agriculture,

[7]Natural Capital Committee, 2019. *Advice on Soil Management*. [Accessed 20 June 2020]
[8]ibid
[9]ibid

forestry, and extraction.[10] These peatland degradation activities, combined with more general poor land use management practices, such as grazing, managed burning, atmospheric deposition, and deforestation, have caused emissions from land use to have risen since the 1990s to represent 12% of the UK's 2017 total GHG emissions.[11]

III. Water pollution

Globally, the agricultural sector is the biggest consumer of global freshwater resources, with farming and livestock production using about 70% of the Earth's surface water supplies. Ironically, agriculture is also a significant cause of degradation in water quality.[12] Excess nitrogen and phosphates can leach into groundwater or move via surface runoff into waterways. During wet weather events, fertilisers, pesticides, and animal waste from farms and livestock operations divert nutrients into waterways, which contribute to severe, and potentially life-threatening, algal blooms.

Agricultural run-off high in nitrates and phosphates causes eutrophication, which involves the explosive growth of algae, which, when the algae die off, are decomposed by microbes that take up the oxygen.[13] These microbes create marine dead zones, or oxygen-poor anaerobic regions of the ocean that threaten many fish and other aquatic organisms.[14] Diffuse pollution from agricultural runoff is in direct violation of EU legislation, including the Water Framework Directive (WFD) enacted in 2000 and the 1991 Nitrates Directive.[15]

Agrichemicals from fertilisers negatively impact groundwater and surface water. Groundwater is often freshwater and can serve as a major source of drinking water, along with being a source of agricultural irrigation and a recharge source for wetlands, lakes, and rivers. However, groundwater can also be contaminated by agricultural activity that leads to leaching by nitrates, rendering the water unsuitable

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[10] International Union for the Conservation of Nature (IUCN), 2018. *UK Peatland Strategy 2018-2040*. [Accessed 19 June 2020]
[11] Committee on Climate Change (CCC), 2020. *Land use: Policies for a Net Zero UK*. [Accessed 21 June 2020]
[12] Mateo-Sagasta, J., Zadeh, S. M., Turral, H., and Burke, J., 2017. *Water pollution from agriculture: a global review. Executive summary*. FAO, IWMI, CGIAR.
[13] Moss, B., 2018. The uses, abuses and restoration of standing waters. In: *Ecology of Freshwaters: Earth's Bloodstream.*
[14] de Schaetzen, S., 2019. Organic Agriculture and the Sustainable Development Goals. *Nature and More*.
[15] European Commission, 2010. Water Framework Directive. *EU Publications Office*.

for agriculture and domestic drinking water. Similarly, surface waters are vulnerable to contamination from agricultural activities, with an example being runoff from manure, fertilisers, and pesticides used in agriculture.[16] In August 2017, *The Guardian* reported some agricultural water pollution offences that occurred in 2016, such as the pollution of waterways and land by slurry and the emission of noxious fumes involving dairy farms in the South-west and Midlands.[17] Furthermore, 86% of English rivers did not reach good ecological status in 2016, which was lower than the EU average, suggesting that the UK may not meet the 2027 target in the Water Framework Directive for all water bodies to have a good ecological status.

IV. Trade deficit and global markets

The importance of the UK food sector to the country's economy cannot be understated: the food sector contributes approximately £111 billion a year to the UK economy, the sector accounts for over 13% of national employment as the UK's largest manufacturing sector, and the UK imports around 50% of the total food consumed.[18] With the unquestionable significance of the UK food sector to the national economy, it is necessary to address and reduce any vulnerabilities.

The UK food system is highly vulnerable to disruption due to the interactions of environmental, biological, economic, social and geopolitical factors. The UK imports around half of its food and UK consumers' diets are highly varied, demanding a wide range of foodstuffs available all year round. Extreme weather, changes in trade arrangements and currency fluctuations all affect food availability. The effects of these food systems drivers lead to volatility in food supply, affordability concerns, and food security. We therefore need to enhance our food system's resilience to such shocks and stresses.[19]

According to Michael Bomford of The Post Carbon Institute, a large majority of the vulnerability comes from disruptions in supply chains.[20] The most vulnerable food areas are regions reliant on imports, oil,

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[16] Denchak, M., 2018. Water Pollution: Everything You Need to Know. *National Resource Defense Council*.
[17] The House of Commons, 2018. UK Progress on Reducing Nitrate Pollution: Eleventh Report of Session 2017–19.
[18] Global Food Security, 2017. *Exploring the resilience of the UK food system in a global context*. [Accessed 24 June 2020]
[19] Franco S.C., Keane J.B., O'Connor R.S., Scott-Brown A.S., Wade R., 2020. *Multifunctional landscapes in the UK: tools for policy and practice*. Global Food Security Programme.
[20] Bomford, M., 2020. [PowerPoint Presentation]. Presented on 3 June 2020.

tourism, migrant workers for farming, and areas with large sectors of the population that are traditionally vulnerable, particularly the urban poor and migrant workers.

Policy issues

I. UK regulatory framework

In the UK, the agricultural regulatory framework currently comprises two elements. The first is based on international law promulgated by the European Union (EU), which is either directly applicable to Member States, or implemented through national legislation. The second element is a set of environmental regulations and arrangements that are not derived at the national and sub-national levels directly from EU legislation.[21] At a fundamental level, the fundamental role of environmental regulation is to establish and codify standards to protect the health of both humans and the environment. For this brief, we solely focus on regulations related to England instead of all Devolved Administrations in the UK.

Beyond these regulations, there are two main Codes of Good Agricultural Practice (COGAP) for farmers in England, relating to protecting water resources, soil, and air; and reducing ammonia emissions. COGAP promotes practical guidance documents for farmers that provide tailored advice on suitable actions for individual farm situations. In addition, there are several active farm assurance schemes in England, many of which require farmers to comply with a set of basic regulations. However, with some exceptions, the environmental component of schemes is often limited to nutrient management. Furthermore, there are also UK agri-environmental schemes (AES) that allow farmers to simultaneously produce agricultural production and non-agricultural ecosystem services.[22] The flagship AES is the Environmental Stewardship Scheme (ESS) which promotes paying farm businesses that go above the legal obligations to develop sustainably. The entry level stewardship (ELS) for this scheme is notably

[21] Baldock, D. and Hart, K., 2020. *Risks and Opportunities of a Post- EU Environmental Regulatory Regime for Agriculture in England*. Institute for European Environmental Policy.
[22] Britain, G. and Curry, S.D., 2002. *Farming & Food: A Sustainable Future: Report of the Policy Commission on the Future of Farming and Food*. London: Cabinet Office.

shallow and broad, with the aim of encouraging farm managers to practice environmental conservation while being easy to regulate.

Moving on, delivery and enforcement of environmental regulations with respect to agriculture falls under the responsibility of Defra, the Environment Agency (EA), Natural England, and Local Authorities. The EA's responsibilities include monitoring soils, water, and air; for instance, water abstraction, disposal of pesticides, intensive farming of poultry units. The EA oversees licence and permit issuance and regulation of these resources and practice. Natural England is responsible for nature conservation, including heather and grass burning, breaches of wildlife licences and notices, and pesticide poisoning of animals. Local authorities oversee and enforce laws such as the hedgerow regulations, tree preservation orders and rules relating to public rights of way. At present, the European Commission also plays an important oversight role.[23]

II. CAP and the UK Agriculture Bill

Under the EU's Common Agriculture Practice (CAP), Direct Payments are paid to farm businesses based on the amount of agricultural land they maintain. The CAP was reformed in 2014 to encompass the 'greening' of capped single farm payments, and support for small farms and young farmers. Yet evidence suggests that Direct Payments offer poor value for money and introduce distortionary incentives, which inhibit the development of a productive and competitive agricultural sector that delivers optimal environmental outcomes.[24] Currently, farmers in the UK are highly dependent on the CAP's basic payment scheme. This accounts for 61% of the average annual farm profit of £37,000 from 2014 to 2017 with livestock farms having an oversized reliance on subsidies for more than 90% of profits.[25]

Thus far, the CAP has succeeded at promoting food production in post-war Europe, however, inherent flaws in its design means that this came at massive cost. At its peak, the CAP cost 73% of the EU's budget

[23] Baldock, D. and Hart, K., 2020. *Risks and Opportunities of a Post- EU Environmental Regulatory Regime for Agriculture in England*. Institute for European Environmental Policy.
[24] Defra, 2018. *Moving Away from Direct Payments Agriculture Bill: Analysis of the Impacts of Removing Direct Payments What Are Direct Payments and Why Do We Want to Remove Them?* London: Author.
[25] Abboud, L., 2018. "UK Farmers Prepare for Overhaul to Farm Subsidies after Brexit." *Financial Times*.

and provided nearly half of farm income.[26] Moreover, the costs are not purely financial. Although 25% of CAP support is sourced from its Pillar 2 Rural Development fund, which supports a variety of AES, these have been criticised as poorly targeted, relatively ineffective,[27] and fundamentally compromised by the 75% of funding which goes directly to farms under the more conventionally focused Pillar 1 of the CAP.[28] Thus, in spite of numerous and ongoing reforms, the CAP has resulted in unprecedented levels of environmental damage.[29] For instance, since the UK joined the CAP in 1973, British farmland bird populations have declined by 56% with iconic species such as the corn bunting *(Emberiza calandra)* suffering a 90% decrease in numbers.[30] Additionally, the CAP has allowed neglectful farming practices to occur, for instance, annually farming contributes to three-quarters of sediment load and around 60% of nitrate pollution in UK waterways.[31]

In place of the CAP, the UK Government proposed the Agriculture Bill, which will instead prioritise deploying rewards to farmers who maximise delivering environmental benefits. In other words, subsidies will be given to projects that provide public goods that the market cannot deliver, such as clean water, flood prevention and wildlife preservation. Direct Payments in England will be gradually phased out beginning in 2021, and farms will be supported over a seven-year transition period. Farmers will experience some reduction to their payments from the start of the transition period. In addition, under the new Environmental Land Management system, farms may be able to consider using some of their agricultural land to deliver environmental benefits.

Possible impacts from Brexit and COVID-19 on the sector

[26] Buckwell, A. E., Harvey, D. R., Thomson, K. J. and Parton, K. A., 2019. *The costs of the common agricultural policy* (Vol. 7). Routledge.
[27] Robinson, R. A. and Sutherland, W. J., 2002. Post-war changes in arable farming and biodiversity in Great Britain. *Journal of Applied Ecology*, 39(1), pp.157-176.
[28] Pe'er, G., Dicks, L. V., Visconti, P., Arlettaz, R., Báldi, A., Benton, T. G., Collins, S., Dieterich, M., Gregory, R. D., Hartig, F., and Henle, K., 2014. EU agricultural reform fails on biodiversity. *Science*, 344(6188), pp.1090-1092.
[29] Hart, K. and Bas-Defossez, F., 2018. CAP 2021-27: Proposals for increasing its environmental and climate ambition. *Brussels: Institute for European Environmental Policy*, pp.62.
[30] Donald, P. F. and Forrest, C., 1995. The effects of agricultural change on population size of Corn Buntings Miliaria calandra on individual farms. *Bird Study*, *42*(3), pp.205-215.
[31] Davey, A. J., Bailey, L., Bewes, V., Mubaiwa, A., Hall, J., Burgess, C., Dunbar, M. J., Smith, P. D. and Rambohul, J., 2020. Water quality benefits from an advice-led approach to reducing water pollution from agriculture in England. *Agriculture, Ecosystems & Environment*, 296, pp. 106925.

In lieu of the upcoming departure from the EU, the UK government has pledged to deliver a 'Green Brexit' underpinned by agricultural policies that aim to 'put the environment first'.[32] As discussed in the previous section, this means the UK pulling out of the CAP and the country creating completely novel policies that cater to domestic agriculture. One can argue that the releasing of the restraints of the CAP can serve as an impetus that propels the UK to pursue better tailored environmental and sustainable development goals.

However, it is important to note that there is, and will continue to be a tremendous reliance on trading with EU states, and EU agri-environment schemes and directives.[33] Furthermore, in terms of policy-making, the UK faces considerable difficulties in formulating an agreeable environmental baseline that all four Devolved Administrations can agree on.

Emissions targets

I. International emissions targets: The Paris Agreement and the EU

Perhaps the most groundbreaking multilateral environmental agreement to have taken place, the 2015 Paris Agreement set a new precedent within climate change negotiations.[34] Not only did it revolutionise the existing 'narrow but deep' focus that had so limited the implementation capacity of the Kyoto Protocol almost two decades prior, making the agreement accessible to a much broader range of international actors, but it set a clear target for emissions reductions: 2 degrees. Whilst the impact and scope of the Paris Agreement have been critiqued, both academically and in within policy making spheres (see: the age-old trade-off between broad and shallow participation[35], and game theory

[32] Treasury, H.M.S., 2018. *The green book: Central government guidance on appraisal and evaluation*. London: Author.
[33] Whitfield, S. and Marshall, A., 2017. *Defining and Delivering 'Sustainable' Agriculture in the UK after Brexit: Interdisciplinary Lessons from Experiences of Agricultural Reform*, pp.501–513.
[34] Intergovernmental Panel on Climate Change (IPCC), 2018. Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C.
[35] Barrett, S., 2005. Global Climate Change and the Kyoto Protocol. In: Barrett, S, eds. E*nvironment and Statecraft*. Oxford: Oxford University Press, pp. 359-399.

analyses of international agreements),[36] it certainly had the greatest public and awareness raising impact on climate and environmental change within recent memory.[37]

Agreement to set Nationally Determined Contributions (NDCs) to meet the 2 degrees target (itself a subject of debate amongst industrialists, policy makers and scientists) has meant that many countries have been lenient in their contributions towards the achievement of the goals of Paris.[38] The EU set a broad catchment emissions target in line with its wider 2030 climate and energy framework, which mandates a reduction of GHG emissions by at least 40%, compared to a 1990 benchmark. This is ambitious economically, however still leaves the EU short of meeting the required reductions to stay on track for a warming of only 2 degrees. Whilst the UK is currently covered by the EU's broader regulatory system (including the EU Emissions Trading Scheme or ETS, a cap-and-trade programme that allows countries to exchange 'pollution permits' for cash, idealistically improving overall efficiency through achieving the cheapest and fastest emissions reductions possible geographically),[39] Brexit coincides with the 2020 deadline to agree on the NDCs and, as such, the UK government must soon disclose its new national target in line with the Paris Agreement. These emissions targets have massive implications for the agricultural sector, not least in terms of the economic subsidies provided but also in relation to other environmental policies and investment in rural infrastructure and industry.

II. National targets and current status

Per the 2008 Climate Change Act, the United Kingdom introduced a recurring five-year carbon budget, which acts as a statutory cap on the country's total GHG emissions.[40] In the long run, as updated in 2019,

[36] Keohane, R. O. and Victor, D. G., 2016. Cooperation and discord in global climate policy. *Nature Climate Change*, 6(6), pp. 570-575; Keohane, R. O. and Victor, D. G., 2011. The regime complex for climate change. *Perspectives in Politics*, 9(1), pp. 7-23.
[37] Falkner, R., 2016. The Paris Agreement and the new logic of international climate politics. *International Affairs*, 92(5), pp. 1107-1125.
[38] Intergovernmental Panel on Climate Change (IPCC), 2018. Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C.
[39] Of course there are numerous issues with the cap-and-trade approach, not least the initial 'grandfathering' allocation of permits undertaken by the EU and the potential to create geographical pollution havens, however for the focus of this report these are unnecessary.
[40] Climateactiontracker.org., 2020. *Pledges And Targets | Climate Action Tracker*. [Accessed 16 June 2020]

the UK has also pledged to end its contribution to global warming by 2050, specifically by becoming the first major economy in the world to require net zero emissions of all GHGs.

While the first and second carbon budgets were met, and the UK is on track to meet its third, but not the fourth and fifth budgets.[41] Between 1990 and 2018, UK GHG emissions fell 40% with net carbon emissions standing at 478 $MtCO_2e$ by 2018. Among the 24 indicators of underlying progress in emission reductions, only 7 out of 24 indicators were on track in 2018, while over the course of 2013-2017, only 6 of 21 indicators were on track. Focusing on agriculture, emissions from the sector stood at 45.6 $MtCO_2e$ in 2017, which contributed to 9% of total national emissions. While GHG emissions from the sector have become 16% below 1990 levels, there has been no progress in reducing emissions from agriculture since 2008. Livestock digestion, fertilizer use, waste management, and on-farm energy use account for most of the emissions in the sector.[42]

In 2015, the Committee on Climate Change (CCC), UK's advisory body on the issue, set the target of 1,765 $MtCO_2e$ for the 5th Budget, or the budget period between 2028 and 2032, including emissions from international shipping. The difficulty of reaching set targets in the upcoming Carbon Budget also has been acknowledged by the CCC. The CCC stated that trends that have led to emissions reductions in the past years (including shift to lower-carbon fuels in electricity generation, improving energy efficiency and reduced waste to landfills) will not be enough to reach the 2050 target alone. Therefore, the Central Scenario for meeting the 5th Carbon Budget suggests improvements across the sectors of power, industry, building and so on. Regarding agriculture, the CCC highlighted the importance of reducing N_2O through improved efficiency of fertiliser use, livestock measures targeting methane, waste and manure management and improvements in fuel efficiency of machinery.[43]

[41] Fankhauser, S., 2020. *What Are Britain'S Carbon Budgets?* *Grantham Research Institute On Climate Change And The Environment*. [Accessed 16 June 2020]
[42] CCC, 2019. *Reducing UK Emissions - 2019 Progress Report to Parliament*. [Accessed 16 June 2020]
[43] CCC, 2015. *The Fifth Carbon Budget: The next step towards a low-carbon economy*. [Accessed 16 June 2020]

Analysis

Reducing GHG emissions from the sector

Overview

Policies promulgating support in encompassing support in terms of financial, educational, and labour aspects of the sector are crucial for foundations that facilitate sustainable agricultural development. Firstly, informing stakeholders of the potential benefits of sustainable growth over intensive monocultures can serve to encourage them to transition towards changes in practice.[44] Next, labour policies, in the context of international migration, serve as a crucial pillar of support in the agrifood sector. With the UK's reliance on some 70,000 seasonal migrant labour to harvest domestically grown produce, the current COVID-19 pandemic has revealed the urgent need for mandatory health and safety protection of migrant workers and farmers. Furthermore, alternative agricultural methods, coupled with contemporary technology, can ensure that can increase farm output. These methods are framed in the form of agritech, which is further discussed in the following section.

In order to incentivise stakeholders in the agrifood industry to transition to long-term sustainable practices in the long run, it is necessary to provide immediate benefits to these stakeholders, particularly such as farmers. Sustainable agricultural practices require time to be adapted and consequently demonstrate their impacts. For instance, the adoption of new technologies, education of staff, and construction of facilities require years to solidify, and may not yield results rapidly enough for farmers to maintain operations in the short term. Hence, it is necessary to ensure that essential income and subsidies are provided in the process of increasing productivity. A possible reference could be Canada's AgriStability programme,[45] which provides economic support to farms when there is a fall in the production margin relative to reference margin. In addition, the UK Government can make specially targeted payments to specific sectors within the agricultural industry. Such payments may include emergency relief for a particular farming sector after a difficult period, or more prolonged support for a specified period of several years to allow farmers to plan ahead. Not only would providing an emergency

[44] Mytton-Mills, H., 2018. Reimagining Resources to Build Smart Futures: An Agritech Case Study of Aeroponics. In *Smart Futures, Challenges of Urbanisation, and Social Sustainability*. Springer, Cham., pp. 169-191.
[45] Kimura, S. and Anton, J., 2011. *Farm income stabilization and risk management: Some lessons from the AgriStability program in Canada* (No. 726-2016-49783).

relief fund help mitigate the impact of unprecedented weather events, but it would be hugely supportive for small and medium farms in responding to exogenous shocks such as Brexit and the COVID-19 pandemic.

A. Technological advancements

1. Aquaponics: A system that combines aquaculture with hydroponics and establishes a symbiotic relationship between the two. Aquaponics uses a process that removes waste produced by aquatic life by allowing plants to break down the waste for nutrient uptake and growth. Waste removal reduces the toxicity of the aquatic environment, and thus ameliorates excess nutrients produced by aquatic animals. This increases the productivity of both the aquatic and crop outputs.

2. Hydroponics: Growing plants with nutrient solutions instead of soil, hydroponics focuses on the optimal growth of crops. This leverages water flow structures such as hydroponic towers to recycle water back through crops as an internal loop, until it has been fully absorbed. The technique allows for water savings in irrigation, greater crop density yields, and reductions in nutrient inputs.[46] At the same time, it reduces pesticide and fertiliser costs. However, additional expenses may come in the form of surveillance and maintenance of the system.

3. Aeroponics: Crops are nourished with mist distributing nutrient-laden water. It is an extremely sustainable production method as it utilises minimal energy and requires little maintenance of the growth medium.[47] Consequently, this results in a reduction in base cost of operation and carbon footprint of the crop output. Aeroponics also allows for a high degree of flexibility in terms of design allowing farmers to customise the system according to their individual needs.

4. Precision Farming: Supported by the UK government, the Agri-EPIcenter has completed a Precision Soil Mapping project to increase the uptake of precision farming by small arable

[46] Al Shrouf, A., 2017. Hydroponics, aeroponic and aquaponic as compared with conventional farming. *American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)*, 27(1), pp.247-255.
[47] Farran, I. and Mingo-Castel, A.M., 2006. Potato minituber production using aeroponics: effect of plant density and harvesting intervals. *American Journal of Potato Research*, 83(1), pp.47-53.

farmers domestically. Integrating satellite data with the UK's soil datasets, the map presents an economically viable alternative to farmers who want to implement advanced precision farming methods. Most notably, this map captures the benefits in the advances in proximal and remote sensing technology and modelling of multi-data resources. As such, farmers can reduce the amount of fertilizers they use, target areas of the field necessitating nutrients, and consequently reduce N_2O emissions.[48]

The booming sector of precision agriculture has also seen the establishment of companies that offer drone services to inform decision-making on farms through remote sensing, and imaging and analysis of crop intelligence. Defra has also offered a grant under the Countryside Productivity Scheme for farms towards the use of drone imaging services.[49]

To implement the highly labour-intensive work of precision agriculture, the use of robots has also been explored in the UK. As application of fertilizer at the microdot-level of accuracy can reduce use by 99.9%, agribots with this capability can allow effective implementation of such techniques in family farms which may oversee small or oddly shaped fields. Portsmouth-based Small Robot Company has pioneered the field with its three small robots to provide per plant precision agriculture, using precise, updated data to convert into crop care instructions.[50]

5. Electricides: GHG emissions can also be tackled by replacing herbicides with electricides, a technology pioneered by RootWave. Collaborating with publicly-owned Innovate UK, and funded in part by the European Union's Horizon 2020 initiative, the firm aims to treat deep into the roots of the weed, and ultimately zap weeds away. The technology has also crossed over to the Small Robot Company allowing the automation of weeding.[51]

B. Public private partnerships, investment opportunities, and incentives

[48] UK Research and Innovation, *Project Overview: Precision Soil Mapping*. [Accessed 16 June 2020]
[49] nesta. 2020. *Precision Agriculture*. [Accessed 16 June 2020]
[50] Small Robot Company, 2020. *Blog - Small Robot Company*. [Accessed 16 June 2020]
[51] Rootwave, 2020. *Small Robot Company – Rootwave*. [Accessed 17 June 2020]

In the field of agricultural technology, private-public partnerships have been outlined by the 2013 government Industrial Strategy. Government identified the strategy as one 'led by the industry, working in partnership with the public and third sectors, to unlock long-term investment by business, private investors, foundations and trusts, and Government', with the Leadership Council shaping the strategy and identifying opportunities for industry co-investment. In the strategy, key proposals such as a £70 million government-funded Agri-Tech Catalyst fund, £90 million to establish centres of agricultural innovation, initiatives for coordination and internationalization were proposed[52].

In 2018, the Business Secretary announced a further £90 million in funding to improve supply chain resilience, create Translation Hubs for farmers, businesses and innovators; as well as establishing Challenge Platforms and Innovation Accelerators.[53] The implementation of such initiatives complements the 2013 Industrial Strategy to achieve public support in all stages of Agri-Tech development, from initial academic research, innovation, commercialisation, and to application of farmers.

This structured approach to private-public partnerships across different stages of development, however, fails to address the specific UK context in agritech. Instead, it focuses on a policy of internationalisation and a focus on export opportunities. This can be seen as the majority of projects pursued by Agri-EPI Center have focused on knowledge transfer, export and partnership with international partners. The 2013 Strategy also allocated £10 million specifically focused on international development with the latest Round 9 of the Agri-tech catalyst on food chain innovations in Africa, intended to build capacity and efficiency.

Therefore, private-public partnerships have been lacking in the sector of solutions focusing on the British context, or suitable for rolling out in more advanced markets and agri-food sectors. While initiatives such as a satellite demonstration farm in Paraguay is funded by Innovate UK to 'validate best-of-breed British technologies',[54] growing cloud-based solutions to agricultural management KisanHub has relied fully on venture capital and private sector funding. Moreover, funding from the EU is expected to dry up in the future as Britain exits the Union.

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[52] Department for Business, Innovation and Skills, 2013. *UK agricultural technologies strategy*. [Accessed 17 June 2020]
[53] UK Government, 2018. *Business Secretary Calls For New Tech Revolution In Agriculture*. [Accessed 17 June 2020]
[54] Agri-epicentre, 2020. *Projects – Agri-EPI Centre*. [Accessed 16 June 2020]

Sustainable Intensification (SI) refers to the process where agricultural productivity is enhanced whilst also creating environmental and social benefits. As the UK transitions to a post-Brexit agricultural sector, we believe that the implementation of technological and environmental forms of SI can improve the resilience of the sector. At the same time, it helps to fulfill the United Nations Sustainable Development Goals (SDGs) 2 and 9, which aim to eradicate hunger and promote sustainable industrialisation respectively. Dicks et al. (2019)[55] identified priority SI interventions that were selected by 244 of their respondents, consisting of exclusively farmers. These included forecasting disease and pest outbreaks using weather and satellite data, improving livestock nutrition to optimise productivity and reduce environmental footprint, and providing training for farm personnel to encourage environmental conservation practices.

It was further observed that the adoption of these SI practices was also dependent on their recent development. For instance, precision farming and pest outbreak prediction technologies have a heavy reliance on big data, and hence are considered to be more readily available to farmers in recent times.

Agri-Tech Industrial Strategy

Launched in July 2013, the Agri-tech Industrial Strategy is the guiding government plan to support the growth of the sector. Its aim is to 'make sure the knowledge and insight from the UK's world-leading science base are translated into benefits for society and the economy at home and abroad'.[56]

The strategy is led by industry with the Agritech Leadership Council responsible for shaping the strategy and identifying key opportunities for industry co-investment. The current Agri-tech Leadership Council is made up of 15 members, including four government officials, six directors or senior corporate figures, and five members of the academic community.[57] While representing a diverse array of interests, all six corporate figures come from large-scale enterprises such as Sainsbury's and PepsiCo. Currently the

[55] Dicks, Lynn V. et al., 2019. What agricultural practices are most likely to deliver "sustainable intensification" in the UK? *Food and Energy Security*, 8(1), pp.2048–3694.
[56] Department for Business, Innovation and Skills. 2013. *UK agricultural technologies strategy*. [Accessed 17 June 2020]
[57] UK Government. 2015. *Agri-Tech Leadership Council: Membership*. [Accessed 17 June 2020]

council does not have members from the growing circles of agritech start-ups and independent innovators, the rising venture capital industry funding the leading innovators of agricultural technology, nor representatives of farmers.

The key response of the Agri-tech Industrial Strategy contains seven policies:

1. Improve the translation of research into practice through a £70 million Government investment in an Agri-Tech Catalyst which will provide a single fund for projects, all the way from the laboratory to market. This will include £10 million to deliver international development objectives
2. Increase support to develop, adopt and exploit new technologies and processes through £90 million of Government funding for Centres for Agricultural Innovation
3. Help the UK exploit the potential of big data and informatics and become a global centre of excellence by establishing a Centre for Agricultural Informatics and Metrics of Sustainability
4. Provide stronger leadership for the sector. The Leadership Council gives industry a stronger and more cohesive voice with Government and the science base
5. Build a stronger skills base through industry-led actions to attract and retain a workforce who are expert in developing and applying technologies from the laboratory to the farm
6. Increase alignment of industry research funding with public sector spend by increasing understanding of what is being spent and where
7. Increase UK export and inward investment performance through targeted sector support [58]

Further commitments have also been made by the Government in 2018 outlined in the following measures:

1. New Transforming Food Production Challenge with £90 million of government investment, including the creation of 'Translation Hubs' to bring together farmers and growers businesses, scientists and Centers of Agricultural Innovation to apply the latest research to farming practice
2. Support Innovation Accelerators which will be responsible for exploring the commercial potential of new tech ideas

[58] Department for Business, Innovation and Skills. 2013. *UK agricultural technologies strategy*. [Accessed 17 June 2020]

3. Demonstrating innovative agri-tech projects and how they will work in practice
4. Launching a new bilateral research programme that will identify and accelerate shared international priorities and help build export opportunities for pioneering agricultural-technologies and innovations overseas

With these commitments and policies in place, the government's strategy can be concluded in support throughout the stages of agri-tech development.

1. In the stage of academic research, the Leadership Council is tasked to conduct a comprehensive mapping and evaluation of research funding to increase accessibility, and identify skills needed to support agri-tech research base. Centers of Agricultural Innovation has also worked with the higher education sector and provided facilities for crucial academic exchange in the sector. Bilateral research programmes will also build greater opportunities for overseas-ready technologies
2. In the stage of commercialization, the key Agri-Tech Catalyst supports the 'proof of concept' development of near-market innovations, with projects reaching Technological Readiness Levels (TRL) 4 (Bench Scale Research), 7 (Inactive Commissioning) and up to 9 (Operations), the highest level in the TRL scale.[59] Centers of Agricultural Innovation also play a role in maximizing private sector engagement and co-investment, while Innovation Accelerators provide a greater foundation of success
3. In the stage of implementation, translation hubs, demonstrations and the Centers of Agricultural Innovation serve to bring together farmers on the ground and agri-tech solutions, giving them the key opportunity to familiarize farmers with new technologies and ultimately encourage implementation

Therefore, it can be seen that in the 2013 Industrial Strategy and 2018 commitments to further bolster investment, a comprehensive approach has been taken by the government to establish a clear pathway for agri-tech to advance beyond preliminary academic research, into commercialisation, and ultimately adoption among farmers.

[59] Department for Business, Innovation and Skills. 2016. *BIS Research Paper No.284, Agri-Tech Industrial Strategy: Evaluation Scoping Study and Baseline*. [Accessed 17 June 2020]

The current scope of government policies, however, solely have focused on the aims of better developing the agri-tech industry itself, but failed to consider the crucial opportunity of a British agriculture revival using the agri-tech industry as a springboard.

The government has pursued a strategy mostly aimed to export agricultural technology abroad. With the Catalyst Funds partnered by the Department for International Development (DFID), rounds of investment have been focused on addressing agricultural challenges in emerging market economies. Meanwhile, the Centers of Agricultural Innovation has also mainly pursued collaborative projects abroad, engaging in bilateral research programmes, demonstrations of novel technology, and other activities to promote British agri-tech.

Meanwhile, the implementation of technologies on farmland has not seen greater investment beyond partnership opportunities among agri-tech firms and British farmers with more platforms and centres. Yet greater challenges beyond marketing and promotion needs to be addressed in the UK for wider adoption of advanced agricultural technology.

The three main enablers for a digital agricultural transformation is the use of digital technologies, improvement of digital skills among rural populations, and a digital agripreneurial and innovation culture, particularly among rural populations. Whilst the last of the three is addressed satisfactorily by the UK government, key infrastructure investments in the first two sectors remain lacking. Whilst British higher education attendance is at a high level compared to most of the world, the rate of attendance among rural areas is just above 40%, which is 20% lower than that of urban areas.[60] Meanwhile, despite the Center of Agricultural Innovation's active involvement in piloting schemes to improve rural infrastructure, there is a lack of capacity to create wholesale improvements across the country. Using the example of the growing 5G connectivity in the UK, while the Agri-EPIcenter has partnered with CISCO in the 5G RuralFirst project, the conclusion of the project has only seen data being handed off to Ofcom, the relevant British regulator.[61]

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[60] Food and Agriculture Organization of the United Nations (FAO), 2019. *Digital Technologies in Agriculture and Rural Areas*. [Accessed 18 June 2020]
[61] 5gruralfirst. 2020. *Our Project Comes To An End, But Leaves A Strong Legacy – And A Brighter Future | 5G Ruralfirst*. [Accessed 18 June 2020]

New trends in the investment of agri-tech have also emerged between 2013 and 2020. Across the Atlantic, agri-tech has seen an exponential growth led by private capital. In the US, the agri-tech sector has seen expansion in the number and diversity of companies, and thus providing a growing source of investment for venture capital, private equity, and strategic players. Since 2014, $5.5 billion USD of private capital has been raised for 282 companies in the US and Canada, focusing mostly on plant health and nutrition. Between 2014 and 2018, funding has also risen from $828 million to $1.4 billion, which represents a 13% annual compound growth rate.[62] In Europe, the sector has seen 1,450 deals invested in 2018 alone, reaching $17 billion USD in 2018, an increase of 70% compared to 2017 figures.[63] Both the United States and the EU observe a fragmented investor base with the majority of investors being generalist tech investors instead of a growing number of dedicated funds focused on agri-tech.

The projections for the agri-tech sector within the United Kingdom have also been conservative compared to real-world trends. Employment in agri-tech as a whole is projected to fall by 2030 due to falling employment in core agriculture, with a moderate growth on the value-added of agri-tech by an average of 0.75% per annum between 2013 and 2030.[64] With the emergence of a new investment climate in the sector, the policies formulated in 2013 may quickly become out-of-touch with reality.

Therefore, improved focus and greater support from the government can provide the accelerating momentum the agri-tech industry needs to thrive and contribute to reduced GHG emissions in the UK. Beyond technology, the agricultural sector also requires significant action in addressing the degradation of landscapes in the country, another great environmental challenge.

Restoring degraded landscapes in the UK agricultural sector

Overview

Existing UK (and encompassing EU) legislation governing farmland can be split into landscape management, landscape restoration, and the farming practice subsidies that incentivise good management and gradual restoration. As outlined previously, the UK is currently host to the EU's CAP and as such subject to supra-national governance. The forthcoming post-Brexit withdrawal from the CAP and uptake of the Agricultural Bill, however, brings with it a different approach. Most notably, the inclusion of subsidies for natural capital previously externalised from market-based calculations.

Gradual phasing out of the CAP's 'Direct Benefits' to farmers has the potential to disincentivise good agricultural practice through reducing the payments they receive. The UK specific alternative promises to offer a more environmentally targeted approach that focuses on previously unquantified (and therefore potentially untapped) socio-environmental benefits. In the wake of COVID-19, ensuring existing landscapes are not only well maintained but also resilient is of paramount importance, especially with the propensity for panic buying and the need to build up localism potential within the UK food industry as a sort of supply backstop.

Landscape management policies vary between national and local scales, with some overarching dictats translated into more specific policies by local countryside authorities and those with jurisdiction over specific types of land (e.g., SSSIs, AONBs, National Parks). The new Environmental Land Management system is a broad policy that promotes using a certain percentage of farmland purely for socio-ecological benefit, with supporting research suggesting that doing so does not reduce productivity for the overall lot and in fact strengthens ecosystem resilience. More specific land management policies are implemented by these smaller agencies, and can include local biodiversity conservation legislation (e.g. keeping fewer sheep per hectare) that targets specific landscape types. Supporting subsidies for more sustainable landscape management allow farmers to make socio-environmentally more logical choices, without compromising directly on economic efficiency.

These policies have some of the most promising futures in building ecosystem resilience and contributing to a more sustainable future of agriculture. Restoration of forests, wetlands, peatlands, heather moors and pasture land has the potential not only to sequester large quantities of CO_2, but helps to combat declining biodiversity. Specifically, land restoration provides habitats for numerous indigenous species and encourages a greater diversity of landscape across the UK (something necessary for a MFL approach.

Restoring landscapes at the catchment level

There is much potential for the UK agricultural sector to become involved in climate change mitigation. According to Smith et al. (2007a), much of the agricultural sector's technical potential involves the following breakdown: 89% from soil carbon sequestration, 9% from mitigation of methane and 2% from

mitigation of soil N_2O emissions. This suggests that the agri-food sector's climate change mitigation approaches should focus on transforming land use cover and management. In particular, there is much potential in restoring degraded landscapes in the UK as a means to promote environmental services and to mitigate GHG emissions.

In implementing these landscape changes, such as the restoration of forests and peatlands, it should be considered that the protection of land for protection and conservation purposes can mean less land and labor available for food production. Furthermore, landscape changes involve multiple landowners — it costs money and resources for government oversight to manage these multiple landowners and ensure that they all work together. Thus, policies that promote the landscape changes must be holistic and ensure that food production is not hampered, financial incentives are sufficient and long-term, and empower farmers rather than render them vulnerable.

This section outlines the benefits of multifunctional landscapes across catchment areas, rewilding and rewetting at farms, and creating partnerships among local communities and the government to create incentives for farmers. A catchment-based approach has been used by the Government since 2011 to manage the environment at the local level and thus to allow more local participation and better inform local decision-making.[65] A catchment approach is favorable in examining ecosystems as the natural environment is full of complex, interrelated systems, with emphasis on facilitation and collaboration among stakeholders.

Building sustainable landscapes: multifunctional landscapes across catchments

Multifunctional Landscapes (MFL) is a theoretical framework that involves sustainably managing multiple ecosystem functions and services. As the name suggests, MFL fulfill a wide variety of needs and functions within a catchment, whether it be food security, livelihood opportunities, maintenance of species and ecological functions; and/or cultural, aesthetic, and recreational needs. As they are typically characterised by diversified land use and complex landscape structure, they can involve many different stakeholder groups and feature a wide range of environmental, social, and economic benefits.[66] In the

[65] Defra, 2013. *Catchment Based Approach: Improving the quality of our water environment*. London: Author. [Accessed June 2020]
[66] Hölting, L., Felipe-Lucia, M. R., and Cord, A. F. (2019). Multifunctional Landscapes. *ScienceDirect*. [Accessed June 2020]

absence of MFL thinking, increasing the provision of one ecosystem service can come at the expense of others. A MFL approach could ensure that decisions are made to sustainably manage multiple ecosystem functions and services so that their provision is optimised.[67]

O'Farrell and Anderson identify several tools and approaches that highlight the cross-disciplinary nature of an MFL approach, such as the incorporation of ecosystem services into economic valuations, the development and advancement of Geographical Information Systems (GIS) to spatially analyse multiple land types, and scenario planning, or examining a wide range of possible future ecological states, socially desirable outcomes and alternatives based on data and models.[68] Essentially, by using an MFL approach to build a sound understanding of how the social, ecological and economic systems relate to one another, a shared future sustainable landscape vision among all relevant stakeholders may be easier to facilitate.

Overall, the MFL theoretical framework is useful in understanding the wide variety of impacts that landscapes can have. Its emphasis on holistic thinking is critical in creating policies that propose changes to how landscapes are used and managed.

Rewilding and rewetting

Under the CCC's latest recommendations, one-fifth of all agricultural land needs to sequester carbon from the atmosphere for the UK to achieve net-zero by 2050. Much of this can be achieved by promoting rewilding and rewetting on farms. Rewilding involves restoring land and soils, planting trees, building natural corridors for biodiversity protection, and encouraging the reversion of cropland to another land cover, typically one similar to the native vegetation, as an effective method of reducing emissions.[69] Rewetting involves restoring the condition of drained wetlands by restoring the hydrology of such bodies, such as peatland, and like rewilding, converting drained croplands back to wetlands can result in reduction of emissions through the rapid accumulation of soil carbon.

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[67] Franco S. C., Keane J. B., O'Connor R. S., Scott-Brown A. S., Wade R., 2020. Multifunctional landscapes in the UK: tools for policy and practice. Report produced for the Global Food Security Programme. March 2020. *Global Food Security Programme*. [Accessed 19 June 2020]

[68] O'Farrell, P. and Anderson, P., 2010. Sustainable multifunctional landscapes: a review to implementation. *ScienceDirect*.

[69] Smith, P., Martino, Z., and Cai, D., 2007. 'Agriculture', in *Climate change 2007: mitigation*. *IPCC.*

The UK has already done work regarding these two fronts, especially in forestry. In the 2019 Conservative manifesto, under the Nature for Climate fund, £640 million would be invested to capture carbon by increasing woodland and restoring peatland.[70] Furthermore, the UK government has pledged to triple the rate of tree planting in the UK to more than 100 square miles a year by 2025, or planting at least 30 million trees a year.[71] This is a step towards climate change mitigation and contributes to the country's 25 Year Environment Plan; however, alone it will not be enough for the UK to meet its net-zero goal: annually adding 42,000 hectares of new woodland upto 2030.[72]

Moving forward, more can be done in promoting the restoration of peatlands and other wetlands. Peatlands are a type of wetland largely composed of semi-decomposed organic matter and they provide a wide range of ecosystem services, such as wildlife habitat, carbon storage, drinking water filtration, flood prevention, and grazing land. Peatlands cover 10% of land in the UK and are a critical carbon sink, and thus are the type of terrestrial ecosystem with the highest carbon density on Earth. The vital importance of peatland and safeguarding the lands has also been designated under the Ramsar Convention. However, peatlands must be drained to make way for food production, and this reduces the extent of ecosystem services that peatlands can provide. Consequently, the restoration of drained peatlands and their conservation are key climate change mitigation strategies.

The International Union for Conservation of Nature (IUCN) UK Peatland Strategy has announced goals that it aims to achieve by 2040. Specifically, it aims to deem two million hectares of peatland in good condition, to support the promotion of policies that prevent the intensification of artificial drainage and direct habitat destruction, and to promote more environmental assessment processes designed to include the costs to carbon, water and biodiversity.[73] The goals of the organisation provide a useful framework for understanding the type of laws and metrics necessary for the UK Government to increase its actions toward rewetting and should be adopted. In general, however, it should be kept in mind that because land cover conversion, whether it involves rewilding or rewetting schemes, should be reserved primarily for surplus agricultural land or on croplands of marginal productivity, as converting the land

[70] The Wildlife Trusts, 2020. Budget 2020 - significant new funding needed to restore nature and tackle climate change. [Accessed 19 June 2020]
[71] UK Government, 2020. Government delivers new £10m fund to plant over 130,000 urban trees.
[72] Venables, C., (2020). Did this budget really 'get it done' on the environment?. *Green Alliance Blog*.
[73]IUCN), 2018. *UK Peatland Strategy 2018-2040*.

means the loss of potential agricultural productivity.[74]

Partnerships and incentives

Agricultural activities aimed at land restoration such as reducing deforestation and restoring degraded lands can help promote the protection, restoration, and promotion of sustainable use of terrestrial ecosystems, sustainable management of forests, and halting land degradation and biodiversity loss. These activities relate to SDG 15 (Life on Land), which focus specifically on managing forests sustainably, halting and reversing land and natural habitat degradation, successfully combating desertification, and stopping biodiversity loss.

In the January 2020 publication, the CCC outlined what it would take for the UK to reduce emissions from agriculture, land use, and peatlands by 64% by 2050 and to achieve carbon neutrality in the UK. Under the CCC's recommendations, a fifth of all agricultural land needs to be used to sequester carbon from the atmosphere, namely by planting trees, restoring peatlands and soils, and growing bioenergy crops with carbon capture and storage (BECCS).[75] For example, 45% of the UK's land is for animal grazing, and a significant proportion of this land is soil poor in nutrients and organic matter -- making it unsuitable for farming -- and underutilised grazing land. One suggestion is to divert funds that go towards paying farmers subsidies to graze on these lands and to turn them into carbon sequestration or rewilding payments. This would allow farmers to continue using the land but in a way that also mitigates climate change.

Additionally, more partnerships can be established to promote agricultural practices that promote biodiversity practices, such as using financial incentives to promote the adoption and use of passive solar greenhouses, agroforestry, hedgerows, and bird and insect habitat.

[74] Smith, P., Martino, Z., and Cai, D., 2007. 'Agriculture', in *Climate change 2007: mitigation*. *IPCC.*
[75] CCC, 2020. *Land use: Policies for a Net Zero UK*. [Accessed 19 June 2020]

Recommendations

1. Create targeted payments to sectors in the industry and emergency climate relief funds
2. Provide more funding in the agri-tech industry, particularly with a focus on establishing PPPs, to advance technological systems
3. Provide stronger financial incentives to farmers that adopt agroecological practices with socio-environmental benefits
4. Pass legislation to engage farmers in agricultural practices that promote greater nitrogen use efficiency and nitrogen cycling
5. Incentivise farmers to grow protein crops as an alternative to clearing land for livestock and to support growing demand for plant-based diets
6. Encourage farmers to engage in low-carbon farming practices
7. Promote policies aimed at conserving and restoring peatlands, forests, and grasslands by providing financial incentives to land managers

7.1. For peatlands, aim to restore at least 50% of upland peat and 25% of lowland peat

7.2. Pass legislation banning agricultural practices that are damaging to peatlands, such as rotational burning on peatland and peat extraction

7.3. The government should also pass legislation banning agricultural practices that are damaging to peatlands, such as rotational burning on peatland and peat extraction

7.4. Work needs to be done on rewilding this type of wetland given their climate change contribution: "15% of the world's peatlands have been drained for agricultural use, or so that their peat could be burned to power generators, emitting carbon dioxide in the process. The dried-out peatland that's left behind then releases stored carbon into the atmosphere; peatlands now account for almost 6% of annual global human-caused carbon emissions[76]

7.5. Consider rewilding / replanting with native species to increase biodiversity and ecosystem resilience

[76] Nugent, C., 2019. The Best Way to Save Nature? More Nature. *Time*. [Accessed 17 June 2020]

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