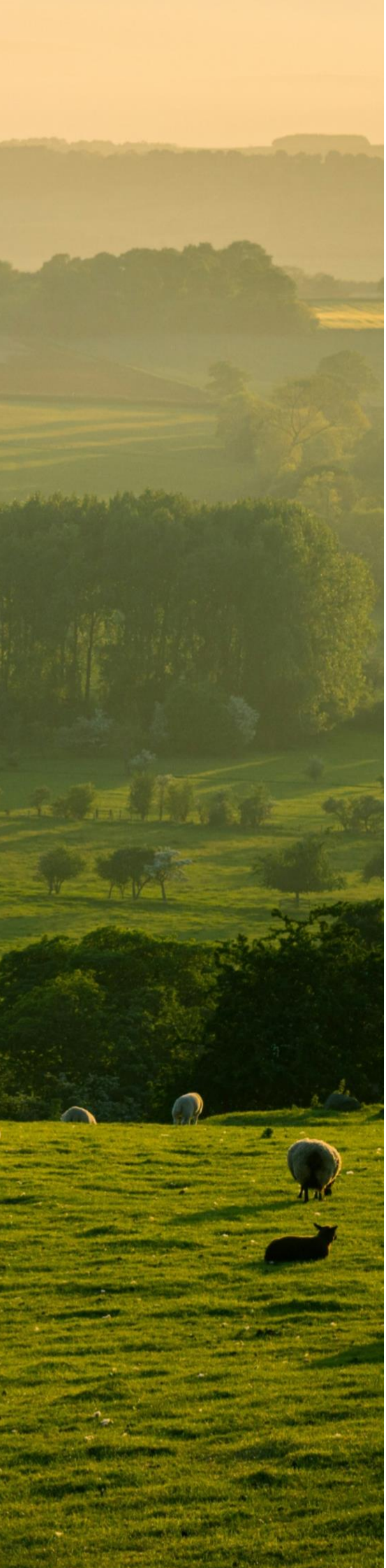

SMALL WORLD CONSULTING

UK Farming and Land Use: Addressing the Climate and Ecological Emergencies while Supporting Farmers

Full Paper

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This paper has been informed by the work we have undertaken with multiple clients, including all UK National Parks, several National Landscapes, private estates, food manufacturers and supermarkets, as well as the Zero Carbon Cumbria project funded by the National Lottery. The views expressed in this paper are our own, and reflect our interpretation of the relevant data, science, policy, and the broader sustainability issues involved.

Contents

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UK Farming and Land Use: Addressing the Climate and Ecological Emergencies while Supporting Farmers

Background

This paper feeds into the contentious debate surrounding how best to enable the UK's farming and land use to evolve in light of the climate and ecological emergencies while supporting farming businesses, families and communities through this transition. It is written for farmers, landowners, governments, trade bodies, NGOs, citizens, and any other interested parties.

The paper is informed by the work Small World Consulting has undertaken for multiple clients over a number of years, including all UK National Parks, several National Landscapes, Local Authority districts, counties and private estates, as well as food manufacturers and supermarkets. It draws on a wide body of peer-reviewed scientific research including our own, government and industry reports, and other relevant sources. It is also informed by conversations we have had with multiple stakeholders including individual farmers, the NFU and other industrial bodies, local and national government officials, civil servants, scientists, consultants, citizen assemblies, and media.

This document contains the full paper with detailed responses to the 15 questions introduced in the companion Executive Summary document.

Fifteen common questions about sustainable UK farming

1. How should the debate on the future of UK farming be conducted?

2. How do we effectively support farmers through the transition to a more sustainable land use and food system?

3. What is regenerative farming, and what role can it play in the transition to a more sustainable agriculture?

4. How much do methane emissions from livestock contribute to climate change, and what do the accounting metrics GWP100, GWP20 and GWP* say about this?

5. In situations where land isn't suitable for crop growing, does livestock grazing represent a good alternative?

6. What impact does livestock grazing have on important biodiversity habitats?

7. What is the current environmental impact of arable farming, and how does it compare to livestock grazing?

8. How does pasture-fed cattle compare with intensively farmed cattle from an environmental perspective, and at what numbers is it sustainable?

9. What is the environmental impact of imported meat when compared with locally produced meat?

10. What impact does substituting dietary beef with chicken, pork or fish have on the environment?

11. What impact will any reduction in livestock production have on food security?

12. What role can technology play in reducing farming emissions?

13. What role do indoor horticulture and vertical farming play in shaping the future of food production and its environmental impact?

14. How sustainable is the amount of meat and dairy in the current UK and global diets?

15. What conditions would nudge people to shift their eating habits towards more sustainable options?

In arranging the questions, our aim was to offer a logical progression, commencing with a broader overview of sustainability issues around UK farming and land use and gradually delving into more specific environmental and agricultural issues. However, it is worth noting that these questions do not need to be read in sequential order. Readers can explore topics based on their specific interests without having to read the entire report.

How our responses to the fifteen questions are structured

We attempted to structure our answers to the key questions about UK farming and land use in a manner that aligns with the principles for engagement outlined in the opening Question 1, the aim being to support evidence-based debates on the subject. To achieve this, our approach is to answer the questions by applying a well-defined structure comprising three essential elements: Context, Answer, and Evidence.

To illustrate this structure, let's consider Question 9 from our list of 15. The brief example context, answer, and evidence summaries presented here offer a snapshot of the full, more nuanced responses given in the sections below.

Example Question: "What is the environmental impact of imported meat when compared with locally produced meat?"

Firstly, the Context section sets the stage by providing a broad overview of the topic at hand, including its significance, various viewpoints, potential misconceptions, and relevant background information. It aims to give readers a comprehensive understanding of why the question is important to ask and the broader context in which it is situated.

Example Context:

> *This question arises from concerns about the environmental impacts of meat production, including GHG emissions and land use change, and the differences in these impacts between the UK and other countries. It considers the environmental consequences of global food supply chains as well as the role of consumption, including dietary choices.*

Secondly, the Answer section presents a clear and concise response to the question posed, drawing upon the most robust scientific evidence available. While it outlines our understanding of and response to the issue, the key arguments, analyses, and conclusions are derived from current scientific evidence, providing readers with a well-reasoned perspective on the topic.

Example Answer:

> *The answer is nuanced and depends on the type of meat considered. In many cases, UK-produced meat is significantly less carbon-intensive than imported meat, although this depends on supply chains of any feed supplements for UK livestock, including for predominantly grass-fed animals. Certain types of UK-produced meat stimulate demand, either directly or indirectly, for feed supplements sourced from deforested regions. In general, local UK meat nearly always makes a higher contribution to climate change than plant-based alternatives. Furthermore, all meat production worldwide requires considerably more land and tends to have a bigger impact on the climate than plant-based sources of food. Reducing meat consumption is necessary for mitigating climate change and reversing biodiversity losses.*

Thirdly, the Evidence section summarises the sources used to support the arguments and conclusions presented in the Answer section. It includes references to scientific studies,

statistical data, industry papers and government reports, giving readers a transparent overview of the sources that we relied upon while carrying out the analysis.

Example Evidence:

- *Sources that look at the higher carbon emissions from imported meat compared to UK meat include publications by the Climate Change Committee (2020) and Poore & Nemecek (2018).*
- *There is plenty of evidence that vegan, vegetarian or low-meat consumption diets could significantly reduce global emissions and land use requirements from the agricultural sector. See e.g. Kozicka et al. (2023), Costa et al. (2022), Chen et al. (2022), Barthelmie (2022), Chan et al. (2022), Poore & Nemecek (2018), Springmann et al. (2018), and Hedenus, Wirsenius, & Johansson (2014).*

1. How should the debate on the future of UK farming be conducted?

Context

Why we need an informed debate about the future of UK farming and land use

For millennia farmers have played a critical role in managing land to meet essential human needs and feed a growing population. In the UK they have kept the nation fed through wars and responded to various crises, both economic and health-related. In recent decades, they have been incentivised or even mandated into particular practices, through EU and UK government regulation and subsidies as well as market pressures including the intensification of arable and livestock systems, removal of hedgerows, and adoption of technology to enable yield increases. We now understand that many of these intensification practices do not best serve either people or planet.

In the 21st century, we have an even bigger ask of farmers: to feed us better than ever and simultaneously look after nature and climate. A modern sustainable food and land system needs to optimise for multiple objectives, including:

- Food production ensuring food security and improved nutrition
- Climate change mitigation and adaptation
- Nature recovery including enhancing biodiversity
- Farmers' and food growers' livelihoods

How best to meet these joint objectives is complex. It requires changes in farming practices, in diets and in government support and incentives, in response to evolving and complex science. High-quality decision-making is essential, and with that in mind, we propose some core principles, which we hope will enable all stakeholders engaging in the debate to play a constructive role. In writing this paper, we strived to adhere to these principles ourselves, and we remain open to evolving our views on various issues discussed here if and when further evidence emerges.

A truly sustainable food system will require co-operation between farming, government, the general public, NGOs, and non-farming businesses. Where there is misalignment, the next steps will be to work for closer alignment while being pragmatic about what is possible in the meantime. In the absence of sufficient and coherent government support, it is impractical for all farms to adopt optimal sustainable practices. We intend this paper to equip all relevant parties with the best science and hope that it will strengthen farmers' case for the support they need in order to be able to farm more sustainably, while doing whatever they can in practice on their farms in the meantime.

Answer

Principles for those engaging in the debate

The complexity and importance of the future of the UK's food and land system demands the highest quality of decision-making and co-operation across many stakeholder groups. Yet several

factors threaten to inhibit this. Firstly, there is the understandable emotional charge that is felt by many, especially where livelihoods, communities and traditions are felt to be at stake. Secondly, the debate is confused by the emerging and complex nature of the scientific evidence. Adding to these difficulties has been the threat of misinformation from some actors with commercial vested interests – a threat which we should take seriously since it has plagued policymaking in other industries, such as tobacco and fossil fuels. Alongside many thoughtful and respectful actors right across the debate, we have also seen examples of entrenched polarisation, well-intentioned misunderstanding of scientific evidence, and mischievous and misleading representation of evidence.

Furthermore, this debate takes place at a time when the UK is perceived by many to be plagued by a culture of political carelessness over facts, and to have seen nationally important debates perverted by misrepresentation.

In order to create an environment which is conducive to high-quality decision-making, we therefore propose the following principles, which we hope can be signed up to by all those engaging in discussion and policymaking on the future of sustainable food and agriculture in the UK.

Principle 1: Honour the best evidence. All parties honour the highest-quality evidence, including the best available science. Key criteria to use when determining what scientific evidence to trust should include:

a) The scientific credentials of any source.
b) Independent peer review by the academic community.
c) Understanding of any partisan loyalties to particular interest groups, including funding and affiliation. When assessing evidence, all parties should take account of the potential for sources to be influenced away from the best interests of people and planet by the financial and other interests of the source.
d) Whether or not the source considers global systemic challenges and constraints associated with land use and food systems (e.g. climate change, biodiversity loss, availability of land).
e) Applicability of the finding to specific local circumstances when account is taken of the UK's position within the global food system, and within that the wide variety of land characteristics, rural communities and farm types.

This principle includes correcting the record as clearly as is practical anytime facts or evidence have been misrepresented.

Principle 2: Respect all interests. All stakeholders should respect and take account of all interests in a proportionate way. This implies that a diverse range of views and options will be sought and taken into consideration. Where the interests of different groups seem to compete, a pathway should be sought that works for all parties, even if this appears inconceivable at the outset. We understand that taking a proportionate account of the interests of all parties could be difficult to define precisely, but it is a step forward to agree to operate from this principle.

In particular, the debate should positively engage with the farming community to seek their views on how any land-use changes will affect their farming businesses and livelihoods, and ensure they are active participants in the discussion.

Principle 3: Transparency of motive and funding. All those involved in the debate are transparent about their financial interests relating to it, including how they may stand to be affected by different outcomes. All parties should also undertake to be honest, accurate and transparent about why they hold the views they do and the reasons behind the actions they advocate.

Principle 4: Foster open-mindedness. In a high-quality debate, there is a great deal of development of thinking from everyone involved. This needs to be encouraged in ourselves and in each other, as our thinking evolves and as the evidence evolves. This principle is about each of us personally endeavouring to reflect on our own rational and emotional positions and to be open to change in the light of new insights, and enabling others to do likewise. Open-mindedness in the face of good evidence is to be applauded, as it enables better outcomes.

Principle 5: Uphold a culture of honest, evidence-based respectful debate. All parties respectfully work to encourage and insist on these principles being upheld by others. This can be done tactfully and respectfully, but with clarity. Recognising that it can be uncomfortable, especially in situations where some might see honouring this principle entailing a breach of a perceived tribal loyalty, we should especially support those who go out of their way to honour this principle, even when in doing so, they challenge us personally.

2. How do we effectively support farmers through the transition to a more sustainable land use and food system?

Context

Moving forward, the UK Government and the wider public are demanding a lot from the nation's farmers, expecting them to strike a balance between food production, nature recovery, and climate change mitigation and adaptation, while also making a living from their farm businesses. Farmers, whose median age in England was 60 in 2016, are understandably concerned about the necessary changes required to deliver these simultaneous objectives, which will require developing new skills and attracting enough new entrants to the profession. Only a "just transition", ensuring that nobody is left behind, is acceptable.

Over the years, farmers' share of the final sale price of food has eroded because of globalised and extensive food supply chains, leading to over-reliance on government subsidies. As part of the just transition, we aim for farms to become more financially self-sufficient (i.e. minimised input costs), get paid a fair price for their produce, and, where relevant, be adequately supported with government and private-sector funding for any mandated land-use changes (e.g. woodland creation or peatland restoration). Movements are currently building across the UK to redress this balance, including the Transition Movement and Sustainable Food Places. The question posed is therefore pivotal to the broader debate about the future of farming and the need to balance financial sustainability with environmental and ethical considerations.

Concerns often arise regarding the risks that any changes to farming practices and broader land use, guided by environmental considerations, could pose to farmers' livelihoods and to the social fabric of rural areas. These concerns often stem from a tension between the necessity for more sustainable practices, such as reducing livestock numbers, and the practical challenges and cultural values associated with traditional farming lifestyles. There is also the fact that many farms are specialised (e.g. beef, dairy, poultry, pigs, arable), and have many generations'-worth of knowledge on how to farm in these specialised areas. Therefore, diversifying into other agricultural areas (e.g. reducing livestock and introducing arable "cash crop" rotations into a mixed farm system) brings with it uncertainty, which can be disruptive to businesses and stressful for farmers.

It is important to acknowledge that UK farm operations are heavily reliant on agricultural subsidies. In the latest DEFRA Farm Business Income statistics for England (2022/23) across all farm types, the Basic Payment Scheme (BPS) accounted for 24%, and agri-environment and other payments accounted for 10% of total "farm business income" (a proxy for Net Profit). Therefore, these two subsidies jointly contributed to 34% of the total income. Diversification out of agriculture (e.g. holiday homes, wedding venues, glamping, etc.) accounted for a further 20%, meaning that net income from farming activities themselves accounted for less than half of total Farm Business Income (47%) at just £45,400 per annum for an average farm.

Figure 1 below illustrates the average annual earnings by farm type, which show the dramatic difference between farm types and their respective reliance on government subsidies. This illustrates that Grazing Livestock (Lowland) and Grazing Livestock (Less Favourable Area – LFA) farm types are by far the most susceptible to changes in government subsidy, with both

categories making a loss on the agricultural aspect of the business (-£8,700 and -£10,400 per annum, respectively). If subsidies were taken out of consideration entirely, then Grazing Livestock (Lowland) would make a surplus of a mere £1,200, supported by farm diversification, whereas Grazing Livestock (LFA) would make a loss of – £7,200.

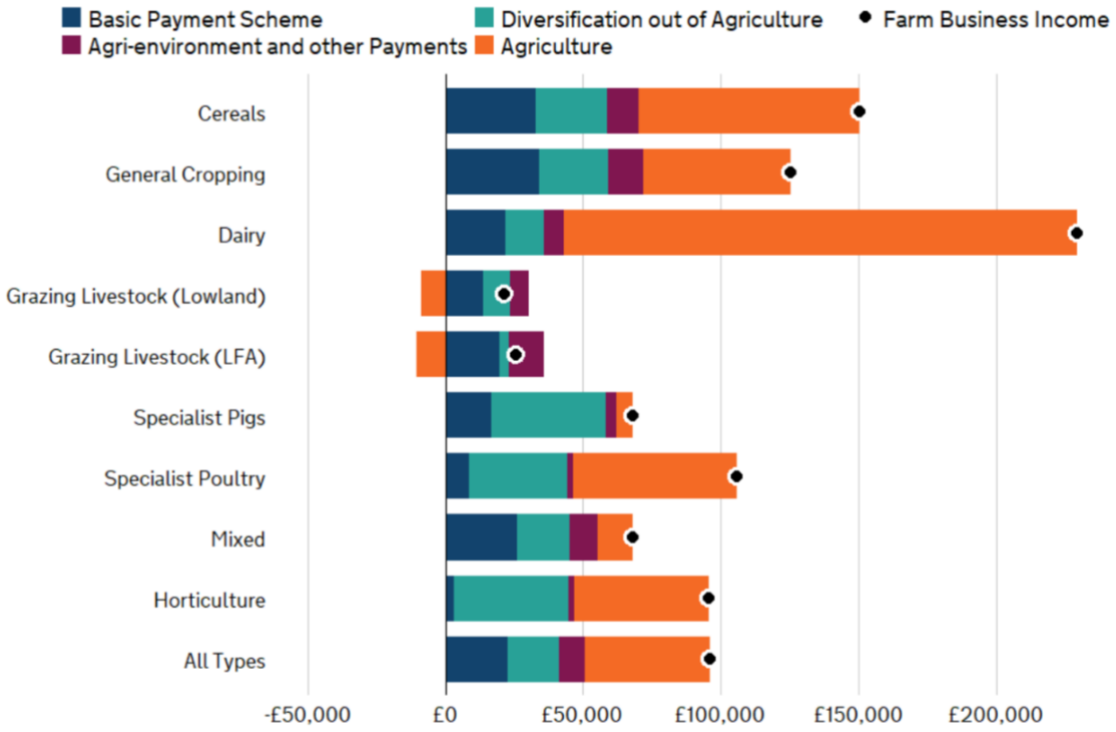

Figure 1. Cost Centre breakdown for Farm Business Income by UK farm type 2022/23. Source: DEFRA National Statistics release "Farm Business Income by type of farm in England 2022/23" (2023). https://www.gov.uk/government/statistics/farm-business-income/farm-business-income-by-type-of-farm-in-england-202223--2

Considering the above, the restructuring of these subsidies poses risks to farmers without adequate support through the transition. Advocates for a just transition emphasise the need to balance environmental concerns with the economic realities faced by farmers, so as to ensure the latter's active participation in shaping a sustainable future.

Additionally, while government subsidies play a significant role, there is recognition of the limitations they pose and of the need for improved financial self-sufficiency. This can come in the form of reducing costly inputs (e.g. feed, fertiliser, fuel, pesticides, energy) and diversified income streams. The latter could include investments from the private sector in the form of carbon and biodiversity credits, provided by companies committed to emission reductions across their value chains, such as those aligned with the Science-Based Targets initiative (SBTi). These investments aim to compensate for residual emissions (usually no more than 10% of the current corporate footprint across the value chains) by funding credible land-based carbon sequestration projects. It is important that this private sector investment supports local communities and does not displace existing farmers from their land.

Overall, the debate highlights the complexities inherent in transitioning towards more sustainable agricultural practices, and the importance of considering multiple perspectives and stakeholders in shaping effective and equitable solutions.

Answer

It will be important to support farmers through this transition period to ensure that they continue and thrive in the future, while also making the changes needed to address the climate and ecological emergencies. The data covered earlier (Figure 1) illustrate the particular reliance of livestock farmers on the BPS, which is in the process of being phased out. However, the same data also show that other farming types (particularly Cereals, General Cropping and Horticulture) do better financially than straight grazing livestock farms. With the right training and support to diversify their farm businesses and simultaneously reduce costly inputs, these existing livestock farms could become more financially resilient, thus improving farmer livelihoods as well as delivering the much-needed ecological improvements. This support will be essential, as switching enterprises in farm businesses is a big challenge in terms of the risk, capital and skills.

Calls to reduce livestock numbers stem both from global land and food system constraints (see Question 14), and from climate impacts of livestock-related emissions, which account for nearly 20% of total human-induced climate warming to date if methane, nitrous oxide and CO_2 emissions (mostly from pasture conversions) are all considered (Figure 3). These calls have understandably caused concern among UK farmers, whose livelihoods and communities undoubtedly need to be supported and protected in a transition to more sustainable land management and food systems. Subsidies such as the Environmental Land Management Scheme (ELMS) in England and the Sustainable Farming Scheme (SFS) in Wales, which will fully replace the Basic Payment Scheme (BPS) in the coming years, are designed to promote environmental enhancements, carbon reductions and improvements in animal welfare, and demonstrate a policy push towards increasing environmental services on farmland. These ELMS-type subsidies, as well as any suitable private-sector investments, need to ensure that farmers receive enough financial support not only to carry out the necessary management of their land, but also to have healthy, thriving lifestyles and communities.

It also needs to be recognised that the challenges go beyond financial support, as many cultural values and place-based identities are attached to certain farming practices and pastoral landscapes. This is a difficult issue to resolve, since a transition to sustainable agriculture in the UK will necessitate at least some changes to these landscapes and farming practices. However, these cultural values and identities are already threatened by the impacts of climate change, and this is affecting farmers' well-being and mental health today. Such problems will only be exacerbated under a worsening climate, with increased flooding, heatwaves and droughts affecting agriculture in the UK and around the world. More concerning, tipping points like a collapse of the Atlantic Meridional Overturning Circulation (AMOC) may occur in just a few decades' time if current rates of global GHG emissions are not drastically reduced. If crossed, the AMOC tipping point in particular would dramatically alter the UK's climate, and likely decimate agriculture and food production in this country.

Farmers have always been central to feeding the nation, and also act as the custodians of large swathes of the British countryside. With the right support across policy and society, they will

have the opportunity to lead the rest of society in a sustainable farming and food system transition, while also safeguarding their own livelihoods and communities against the devastating impacts of climate change. An approach to leading this transition through regenerative farming is covered in further detail in Question 3. Regarding financial support, particular attention should be paid to tenant farmers, who make up a large portion of the agricultural sector in the UK but who are not in a financial position to make these transitions without increased support and guarantees against risk.

Evidence

- Farmers are concerned about shifts in subsidies, since many small and medium-scale farms rely on these funds to turn a profit. This means there is potential for well-designed subsidies, aligned with climate targets, to protect farmers against current uncertainties. See e.g. Winter et al. (2016), Arnott et al. (2021), O'Neill et al. (2020), and Flack et al. (2022).
- It is important to note that these debates can often extend beyond mere financial concerns since cultural values and place-based identities are equally affected, as highlighted in this blog article published by BMC, as well as in academic literature. See e.g. Holmes et al. (2022), Wheeler et al. (2018) and Mather (1996).
- Decisions should be made keeping in mind that farmers, farming communities and our global food system are equally (if not more than other sectors) under threat from climate change tipping points themselves. See e.g. Geoghegan et al. (2012), Tschakert et al. (2017), Naylor et al. (2019), Howard et al. (2020b), and Ritchie et al. (2020).
- For a detailed breakdown of Farm Business Income by type of farm in England 2022/23, see these national statistics by DEFRA (2023). A relatively recent survey of agricultural labour in England can be found in Farm Structure Survey 2016 by DEFRA (2016).

3. What is regenerative farming, and what role can it play in the transition to a more sustainable agriculture?

Context

The question of whether agricultural GHG emissions can be offset by soil carbon sequestration, particularly through regenerative farming practices, is important because it addresses potential strategies for mitigating agriculture's contribution to climate change while improving soil health, as well as creating broader environmental benefits. Unfortunately, there are also misleading claims being made in both the academic and wider literature on the potential of offsetting livestock emissions purely through soil carbon sequestration. Thus, this question might also result from uncertainties about the feasibility, effectiveness, and potential trade-offs of regenerative farming, highlighting the need for evidence-based approaches to address both food production and environmental sustainability goals.

“Regenerative farming” is a common term for a relatively recent approach to agriculture that focuses on enhancing microbial and mineral soil health, biodiversity in cropland and grassland habitats, water cycling and retention in soils, and plant solar energy capture. This is achieved through a range of measures including minimal soil disturbance, sophisticated grazing plans with long rest and recovery periods for plants, and agroforestry, among others. Across Europe, “agroecology” is the term more commonly used to describe these practices. One of its most significant supporters is the Food and Agriculture Organization (FAO) of the United Nations, which in its 2018 report “The 10 Elements of Agroecology” defined agroecology as “an integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of food and agricultural systems. It seeks to optimize the interactions between plants, animals, humans and the environment while taking into consideration the social aspects that need to be addressed for a sustainable and fair food system”.

Closer to home in the UK, various voices, including those behind initiatives like the Dublin Declaration and the NFU’s Net Zero strategy, advocate for soil carbon sequestration as a significant component of climate change mitigation efforts. In support of this there have been high-profile films such as “Kiss the Ground”, which highlights the benefits that regenerative agriculture can bring in a broad sense (i.e. biodiversity improvement, farm financial sustainability and soil health). Proponents of this approach also focus heavily on the positive impact that regenerative farming can have on the carbon balance of agriculture by reducing GHG emissions and increasing carbon sequestration. Principally this is achieved by reducing cultivation (no-till), adding new organic matter and avoiding overgrazing. However, the claimed levels of carbon “drawdown” (i.e. soil sequestration) are often in ranges that are not supported by the current scientific literature, and ignore the equilibration of soil carbon that is well known to occur a couple of decades after a regenerative practice is first introduced. While regenerative agriculture is recognised for its ability to enhance soil health, claims that grazing systems alone can fully offset livestock emissions lack universal support. Many experts also warn against viewing soil carbon sequestration as a singular solution, and highlight the importance of understanding its limitations within a broader context.

Answer

Focusing specifically on GHG emissions, it is true that herbivores can aid soil carbon sequestration by stimulating organic matter production and turnover, and in a very few specific cases this may help offset the emissions from grazing livestock itself (within the same area of land). The levels of carbon sequestration resulting from regenerative practices are currently being assessed by the scientific and farming communities, and some emerging results show good promise, particularly when previous land management history resulted in high potential for additional sequestration.

Despite these considerations, at world scale the global heating caused by livestock-related emissions far exceeds any realistic mitigation potential by soil carbon sequestration. Soil carbon sequestration is also finite, and can easily be reversed in the event of future land degradation (e.g. through erosion driven by extreme rainfall) or unfavourable changes in management practices. Furthermore, while plants may experience faster growth in warmer climates with increased CO_2 levels in the atmosphere (provided that other conditions such as precipitation are right), rising temperatures also accelerate the rate of decomposition of organic matter in soils, which poses a risk to existing soil carbon stocks and may negate the additional plant growth.

Finally, scientific evidence suggests that in many areas of the UK, land that is currently grazed by livestock for meat production would have higher carbon sequestration potential if it were returned to its pre-civilisation natural states (e.g. woodland and peatland – as reported by Natural England) and grazed at low conservation numbers of herbivores. It should be noted that in places such as South Downs and Cotswolds, where calcareous grassland is the most common natural habitat, the greatest biodiversity potential can be achieved through conservation grazing, even though this may sequester less carbon than woodland creation projects. Any nature recovery in these areas also needs to be balanced with the practical challenges of nature conservation and management – currently outside most farmers' expertise – and of maintaining food production to contribute to UK-wide food security.

Looking at the broader picture of regenerative agriculture / agroecology, as covered in the Context section above, when done properly and considerately, the associated practices can lead to multiple benefits compared with conventional agriculture. These include improved water cycles (which assists with drought / flood mitigation), soil health, soil and plant carbon sequestration, and biodiversity. Agroecology also considers the wider social and economic aspects of farm management practices, and therefore can have beneficial effects on the wider local and national food supply chain. However, over recent times and regrettably, the term "regenerative agriculture" has been co-opted in situations where only selective regenerative measures have been adopted (e.g. cover cropping), leading to the whole farm/organisation laying claim to being fully "regenerative". Unlike agroecology which, as mentioned earlier, respected bodies such as the FAO have attempted to define, regenerative agriculture still lacks a clear definition, and therefore is open to misinterpretation and misunderstanding. It is hoped that time will bring more clarity on this, or that the clearer term of agroecology will be adopted in common discourse, as is being practiced by the Food, Farming and Countryside Commission (FFCC) in its reports.

In conclusion, regenerative agriculture "done properly" can play an important role in the transition to a sustainable food system, due to its multiple benefits when compared directly with

conventional agriculture. However, this should be balanced with the amount of land afforded to these practices and the need to make space for nature recovery in the least-productive agricultural areas of the UK, which will help fulfil the requirement to achieve Net Zero GHG emissions.

Evidence

- Notably, the Dublin Declaration (2023) and the NFU's Net Zero Strategy (2019) underscore the significant role of soil carbon sequestration in mitigating GHG emissions from livestock. Nonetheless, our response highlights the risk of overemphasising this approach, as it may foster excessive reliance on a solution with inherently limited mitigation potential and considerable vulnerability.
- In the long run, carbon sequestration in soils will play an important role in compensating for residual GHG emissions elsewhere, which is why it is essential to protect from degradation land areas that currently sequester a lot of carbon. Reducing grazing intensity is one of the measures which supports the ongoing effectiveness of grasslands as a carbon sink. See e.g. Soussana et al. (2010) and Amelung et al. (2020).
- Smith (2014) warns that a more nuanced approach to understanding carbon sequestration in relation to land management is important, as outcomes of empirical studies might otherwise be misrepresented or misunderstood.
- Bossio et al. (2020) explore the potential and limitations of soil carbon as a natural climate solution.
- The limits of soil carbon sequestration are essential to consider. At a global level, grazing systems' emissions outweigh the carbon mitigation potential of soils, and this potential is finite and easily reversed by land degradation. See e.g. Mackey et al. (2013), Godde et al. (2020) and Wang et al. (2023).
- For a range of possible outcomes for soil carbon sequestration under projected future climate conditions and land management in the UK, see e.g. Yumashev et al. (2022).
- Natural England (2021) provides a comprehensive summary of carbon sequestration rates in different habitat types, including woodlands and grasslands.
- Groundswell provides an introductory overview of the principles of regenerative agriculture.
- Jordon et al. (2024) summarise the latest scientific evidence concerning grazing management and soil carbon sequestration. Upon reviewing the most robust science, they also conclude that significant cuts in global per capita consumption of animal products will be essential in order to combat global warming.
- Some evidence indicates that under very specific circumstances and management practices, soil carbon sequestration can completely offset emissions from grazing systems. Stanley et al. (2018) showcase this for a Midwestern US beef finishing system, for example. However, they base their study on the soil carbon sequestration potential observed over a period of only four years, and acknowledge that this rate would likely decline over time as carbon equilibration is reached.
- With regard to simplified narratives that point to soil sequestration as the solution to end all climate problems, like the one from the documentary film Kiss the Ground quoted above, soil scientist Ronald Amundson (2021) has argued that "the embrace of simple happy endings, on issues as complex as soil and climate, is in effect another type of denial of fact."

- The FAO (2018) report "The 10 Elements of Agroecology" provides a broad definition of agroecology, introduces the key principles which underpin the approach, and shows how agroecology nests within the wider United Nations Sustainable Development Goals (SDGs).
- The Food, Farming and Countryside Commission (FFCC) has used the term "agroecology" rather than "regenerative agriculture" in all publications since its inception in 2017. This is most prominent in its 2021 report "Farming For Change: Charting a course that works for all" (FFCC, 2021) which summarises research commissioned by the FFCC and carried out by the IDDRI (the Institute for Sustainable Development and International Relations).

4. How much do methane emissions from livestock contribute to climate change, and what do the accounting metrics GWP_{100}, GWP_{20} and GWP* say about this?

Context

The question regarding the global warming potential (GWP) of methane, and specifically about applying a relatively new metric – GWP* – to methane emissions from livestock, arises from concerns over the role of methane in climate heating and the robustness of different greenhouse gas (GHG) accounting methodologies used to set emission reduction targets. This question is important to ask because it sheds light on the need to reduce methane emissions from livestock farming as part of climate change mitigation efforts. However, there are often misunderstandings or misconceptions in the applications of the GWP* accounting, which can lead to differing interpretations of the urgency of reducing methane emissions from livestock.

The debate centres on varying interpretations of GWP*, the limitations of both the conventional GWP_{100} metric and the newer GWP* metric, and the responsibility of countries like the UK to address their historically high levels of methane emissions. Certain proponents, exemplified by organisations like the AHDB, argue that the decline in UK ruminant livestock numbers over recent decades implies that no additional warming has resulted from UK methane emissions over this period, since most of the emitted methane decays in the atmosphere with a half-life of around 12 years. Sometimes, this trend is even presented as a net cooling effect, which in turn is used to argue that it helps the UK to meet its Net Zero targets. However, others point out that while methane emissions in the UK may have decreased marginally since their historic peak, this argument overlooks the cumulative impact of past methane emissions on today's climate. They also point out the very significant warming potential of methane in the short term, and the associated benefits of rapid reductions in methane emissions in order to limit global warming to 1.5°C.

Answer

Methane emissions currently account for approximately 1/3 of the total gross anthropogenic climate heating, and, given the cooling from sulphate aerosols and other emitted substances that offset some of the heating, methane is responsible for nearly half of all the human-made climate warming observed to date (Figure 2). The largest sources of anthropogenic methane are fossil fuel extraction (around 40% of total methane emissions), livestock (around 30%), and landfill and agricultural waste (around 19%). These figures suggest, in conjunction with specialised climate model estimates, that livestock methane emissions currently contribute to around 15% of total human-made warming (Figure 3).

When in the atmosphere, methane absorbs around 100 times more of the Earth's heat than CO_2 per tonne, at any given moment. However, once emitted, methane breaks down in the atmosphere with a half-life of around 12 years (a very small part of it also gets absorbed by specialist bacteria in soils). In contrast, a large part of emitted CO_2 stays in the atmosphere for centuries. Over a 20- and 100-year period after being emitted, one tonne of biogenic methane creates, respectively, around 86 and 26 times more heating than one tonne of CO_2 that was

emitted at the same time. These estimates account for the respective behaviours of the two gases in the atmosphere, and define the commonly used accounting metrics GWP_{20} and GWP_{100}. The estimates are slightly higher for fossil methane since one of methane's decomposition products in the atmosphere is CO_2, which would have been removed from the atmosphere a few months or years earlier in the case of biogenic methane (e.g. to grow the grass subsequently eaten by the bovine animal that produced the methane).

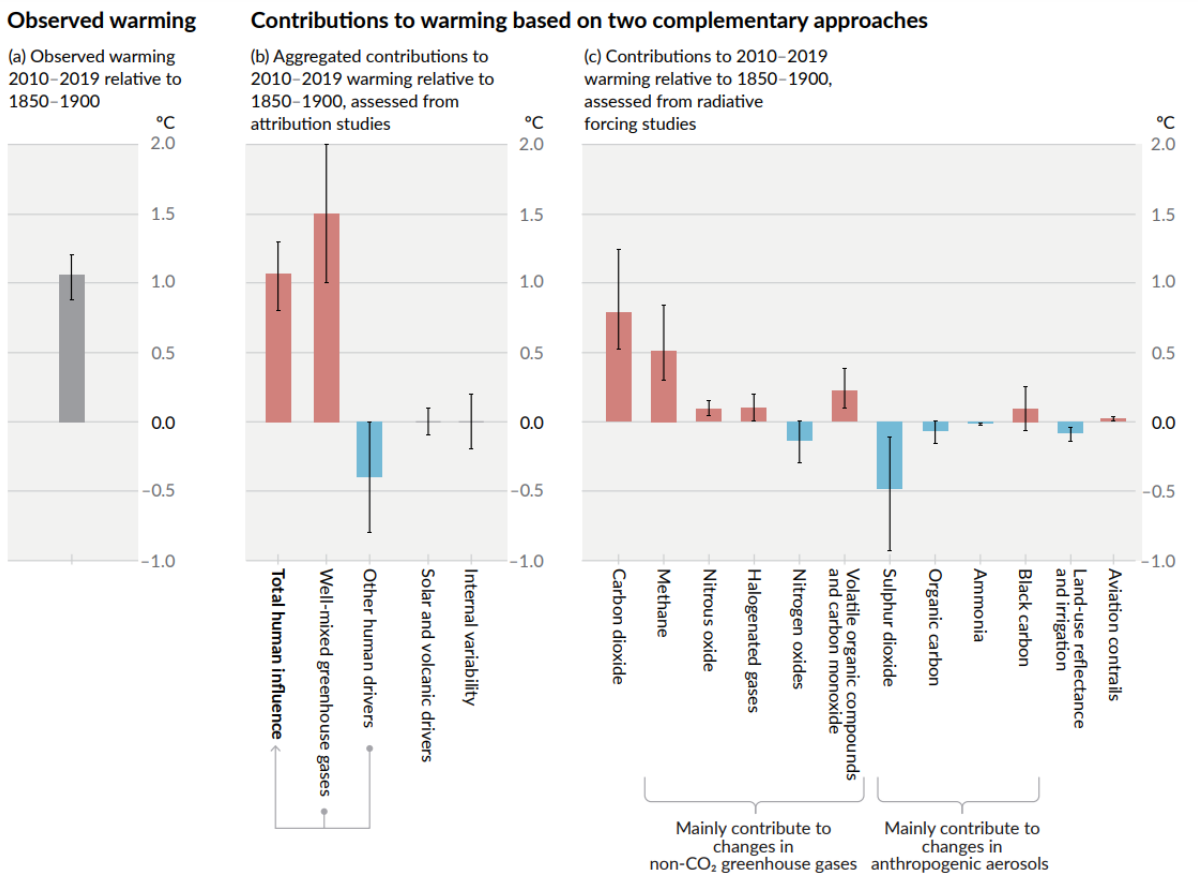

Figure 2. Contributions to present-day climate warming from different greenhouse gases and other human climate drivers. Source: IPCC AR6 (2021), Climate change 2021: The physical science basis. Contribution of working group I to the sixth assessment report of the intergovernmental panel on climate change. https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/

When accounting for a one-off methane emission from a given source such as a ruminant livestock farm, the GWP_{20} and GWP_{100} metrics show the true scale of climate heating caused by this emission over the 20- and 100-year periods compared to CO_2 (86 and 26 times more heating respectively, for biogenic methane). The same holds true when considering a one-off consumption of a product that created methane emissions while being made, for example a beef burger. However, when applied to continued emissions from the same source over many years, or to continued consumption of the same product with embodied methane emissions (e.g. beef burgers) over many years, both GWP_{20} and GWP_{100} fail to factor in the very short half-life of methane in the atmosphere compared to CO_2, which results in methane replacing itself whereas CO_2 accumulates.

The recently introduced GWP* metric attempts to deal with this issue by focusing on relative changes in methane emissions from a given source over a 20-year period. GWP* shows that for

methane, further climate change is driven primarily by changes in annual emissions, whereas for CO_2, further climate change is proportional to the annual emissions themselves. However, by focusing on further climate change (i.e. increases or reductions in climate heating), GWP* ignores the warming that has already occurred from recent methane emissions. This means that it is only a useful metric at the global scale, and that it can easily be misinterpreted. Applying it to a single country, region, industry sector or point source obscures any historical increases in methane emissions, some of which could have taken place well before the 20-year time lag used to define GWP*. Therefore, such applications ignore inequities in current distribution of methane emissions around the world and the resulting warming (Figure 3).

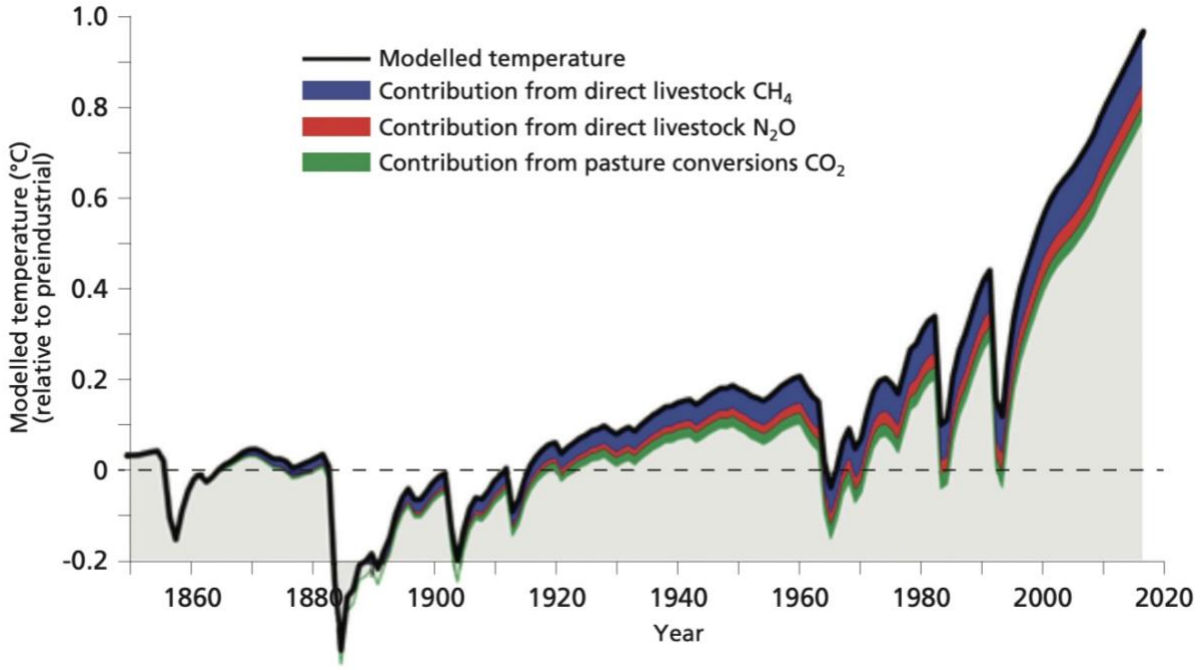

Figure 3. Modelled global temperature anomalies from 1850 to 2015 for all anthropogenic emissions, including from livestock. Source: Reisinger & Clark (2018). "How much do direct livestock emissions actually contribute to global warming?" Global Change Biology, 24(4), 1749-1761. https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.13975. Adapted by FAO for the 2023 report "Methane emissions in livestock and rice systems". https://www.fao.org/3/cc7777en/cc7777en.pdf. Note: This assessment is based on climate models and does not use a Global Warming Potential (GWP) metric.

In the UK, for example, methane emissions are comparatively high, having risen significantly in the past mostly through the growth of livestock numbers, before plateauing around 30 years ago and reducing marginally to their current level. This plateauing doesn't mean the UK's methane emissions are having no impact on the climate, but rather that their contribution to climate heating (a UK equivalent of the global contribution in Figure 3) had already built up in the past and has been maintained at a nearly constant level since the plateauing. It does not absolve the UK of its share of responsibility to reduce its methane emissions, alongside emissions of carbon dioxide and other greenhouse gases.

Because methane is such a potent yet short-lived greenhouse gas, cuts in the UK's comparatively high methane emissions would make a large contribution to reducing its climate heating impact. These cuts, if replicated by other countries with high methane emissions, could help the world avoid triggering climate tipping points, and succeed in limiting global warming to 1.5°C with little or no overshoot, therefore reducing the risks associated with climate change and the need for

costly adaptation. Essential steps to achieve deep cuts in methane emissions include reducing livestock numbers and decreasing emissions from remaining livestock through technological solutions (Question 12), coupled with reducing leakages from oil and gas wells, gas pipes, and landfills (in addition to phasing out fossil fuels and reducing waste altogether).

To move past the largely unhelpful debate about pros and cons of different GWP accounting metrics and the associated fair shares of methane emission reductions, we suggest reporting estimated contributions to current warming from historical emissions separately for CO_2, methane, nitrous oxide (N_2O) and other GHGs (as applicable). This approach has already been piloted at global and national levels (e.g. Figure 3), and it could be adapted to regions, industries and point sources, provided that sufficient historical data are available.

When it comes to setting emission reduction targets, once again, we recommend doing this separately for CO_2, methane (CH_4), N_2O and other GHGs, and separately for different industry sectors, too. A good starting point is a set of global and national pathways from the IPCC's Sixth Assessment Report (AR6) for multiple industry sectors and for multiple GHGs, which are consistent with limiting global warming to 1.5°C with little or no overshoot and were derived without a GWP metric (i.e. using climate models). These pathways are illustrated for the global agriculture, forestry and other land use (AFOLU) sector in Figure 4. The global AFOLU pathways show the necessary short-term and long-term reductions in the CO_2, methane and N_2O emissions associated with farming and other land use. They represent an optimised trajectory for the global AFOLU sector – assuming all other industry sectors are also going to deliver on their respective pathways – and are dominated by stopping deforestation and scaling up reforestation (CO_2 component), reducing emissions from ruminant livestock (methane component), and reducing emissions from synthetic fertiliser use (N_2O component). Of course, any global AFOLU pathways such as those shown in Figure 4 would need to be adapted to a given national and regional context to derive "fair share" targets for land-based emissions.

Evidence

- The assertion, exemplified by the AHDB, that UK methane emissions have not significantly contributed to additional warming over the past two decades is technically accurate. However, this argument carries the risk of neglecting the UK's historically high methane emissions and the associated warming already realised.
- Estimates for the current contribution of methane to climate heating can be found in the IPCC's Sixth Assessment Report (AR6) published in stages between 2021 and 2023. The report also provides global and national mitigation pathways separately for CO_2, methane, N_2O, other GHGs and aerosols, which were derived without GWP metrics by employing climate models.
- For a detailed breakdown of climate impacts associated with livestock emissions, which do not rely on any GWP metrics, see e.g. Reisinger & Clark (2018).
- A comprehensive review of the climate impacts of methane emissions from livestock and other agricultural sources, together with a useful summary of different accounting metrics and of the options to reduce the emissions, has been published by the UN's Food and Agriculture Organisation (2023).
- The latest version of the GWP* metric was introduced by Smith et al. (2021).

- SWC's recent briefing paper GWP*: Applications & Misapplications provides a comprehensive overview of the differences between methane and CO_2, and pitfalls of using GWP*. It also contains links to the essential literature on the subject.
- Donnison & Murphy-Bokern (2024) have also taken a closer look at climate neutrality claims in the livestock sector, and highlight the limitations of GWP* when applied at a sectoral level.
- Jones et al. (2023) estimated country-level contributions to warming from reconstructed historical CO_2, CH_4 and N_2O emissions between 1850 and 2022, with separate sets of estimates for fossil-based and land-based emissions.
- Allen (2015), one of the authors of the GWP* metric, demonstrated the need for early reduction in both CO_2 and methane emission to limit warming to 1.5°C with little or no overshoot.

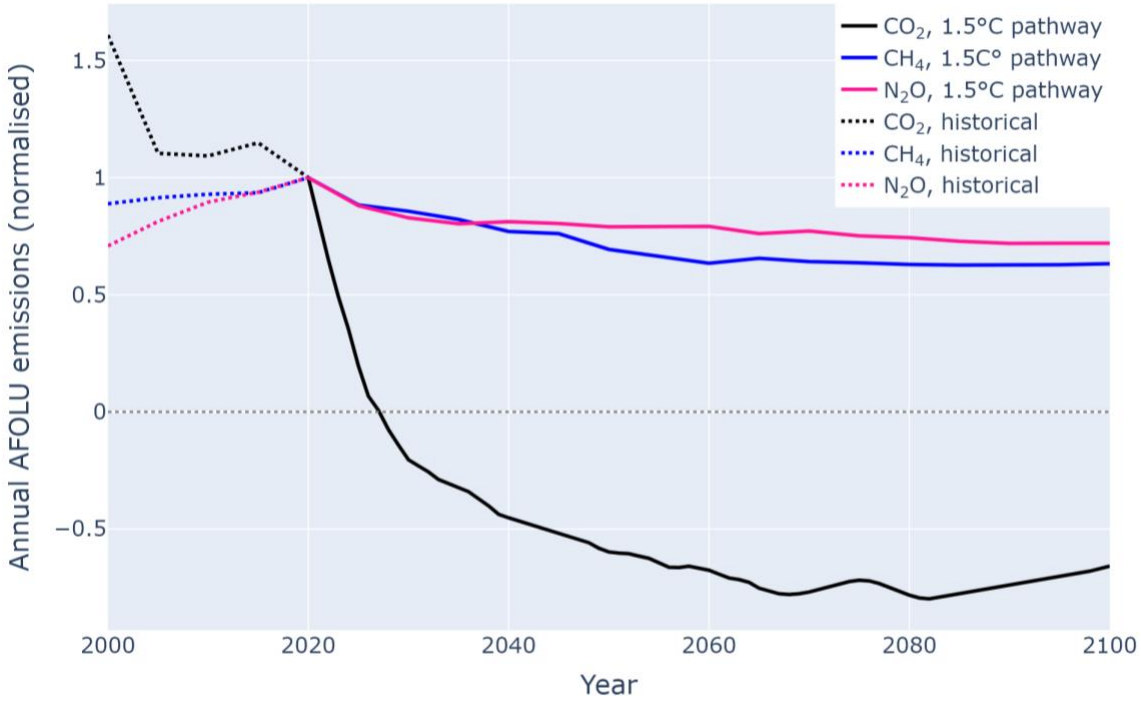

Figure 4. Historical emissions of CO_2, methane (CH_4) and nitrous oxide (N_2O) associated with the global agriculture, forestry and other land use sector (AFOLU), and the corresponding future reduction pathways for each of these gases consistent with the 1.5°C target from the Paris Agreement (with low or no overshoot of 1.5°C). The data has been normalised to 2019. Source: IPCC AR6 (2021), Climate change 2021: The physical science basis. Contribution of working group I to the sixth assessment report of the intergovernmental panel on climate change. https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/

5. In situations where land isn't suitable for crop growing, does livestock grazing represent a good alternative?

Context

It is important to consider whether land unsuitable for crops would best serve for grazing, as this question addresses the challenge of optimising land use in areas where conventional crop farming may not be practical. It prompts considerations about the potential benefits and drawbacks of grazing livestock, such as their impact on soil conservation and greenhouse gas emissions, as well as the economic feasibility of alternative land uses.

Arguments like "most pasture land isn't suitable for growing crops on it anyway" or "humans can't eat any of a typical British beef cattle herd's diet" may sound compelling, and are often employed by proponents of maintaining or expanding livestock numbers. However, this perspective often overlooks alternative land uses that could potentially reduce greenhouse gas (GHG) emissions and increase carbon sequestration, such as reforestation, native woodland expansion, and peatland restoration.

Answer

It is often the case that land unsuitable for crop growing also represents the least agriculturally productive parts of the UK's land, such as the upland areas. Historically, many of these areas would have been peatlands, wetlands or woodlands, and therefore often a more effective use of these areas from a biodiversity and climate change mitigation perspective is to restore them to their natural habitat. Around 20% of the UK (mostly along the west side of England, Wales and Scotland) used to be home to vast temperate rainforests rich in wildlife and biodiversity. However, over the centuries, humans cleared these rainforests for the purposes of timber, firewood and agriculture, which has contributed to the UK's status as one of the most nature-depleted countries in the world. In addition, although less visible (and not in the public consciousness), 80% of natural UK peatlands have been modified as a result of past and present management including for sheep and deer grazing, commercial forestry, burning (e.g. for grouse hunting), construction projects, and commercial peat extraction for horticulture. This has had multiple negative impacts including reduced carbon capture / sequestration, biodiversity loss, and impairment of the peat's ability to intercept and store water, thus increasing the likelihood of flooding events.

Since UK deforestation and peatland degradation happened gradually over long periods of time, we have grown accustomed to the current look and feel of the UK's countryside and are subject to a psychological phenomenon called "shifting baseline syndrome". This occurs through the gradual change in the accepted norms for the condition of the natural environment due to a lack of human experience, memory, and/or knowledge of its past condition. It is perpetuated when each new generation perceives the environmental conditions in which they grew up as "normal". In short, land currently used for grazing or cropping could potentially suit other uses. In particular, land that may not be suitable for growing crops can still be of great value for nature recovery programmes such as woodland creation or peatland restoration, where it could deliver significant climate benefits and help to restore the UK's once rich biodiversity. It should be noted that grazing

could also play a part here in an agroforestry capacity and, with the right support, nature recovery projects could offer diversification opportunities for farmers through enterprises such as eco-tourism, woodland management and conservation projects. Any nature recovery programmes on current farmland will require sufficient financial support and training from the Government, as well as private-sector funding in order to support the farmers and achieve the “just transition” (Question 2).

Evidence

- The quotations employed in the contextual section illustrate prevailing narratives perpetuated by the meat industry that are often uncritically adopted by various sources. In this instance, the cited examples originate from a blog article promoting paleo diets (Paleo Leap, 2023) and a NatWest (2021) publication addressing perceived "myths" about livestock, both of which lack robust evidential support.
- Many publications demonstrate the potential of nature recovery programmes to help reduce GHG emissions and scale up carbon sequestration. See e.g. Burke et al. (2021), Fletcher et al. (2021), and Humpenöder et al. (2020).
- Garnett (2023) points out that livestock farming is a major impediment to the revival of the UK’s temperate rainforests (the UK’s most biodiverse habitat), and argues that this should be treated as seriously as deforestation.
- Barnes et al. (2023), for example, have highlighted the role that rough grazing areas with little other agricultural use play in Europe’s red meat production. While their paper offers insights into mixed livestock systems in marginal agricultural areas, it does not endorse the idea that livestock production in these regions is without environmental concerns. Some farms in these areas show high emissions and low agricultural productivity. Additionally, cattle raised on rough grazing pastures often require supplemental feed, especially in winter. While humans cannot directly consume the forage cattle graze on, it's worth noting that arable land often used for livestock feed production could potentially be repurposed for human food production. Thus, dismissing concerns about livestock production in these areas overlooks broader environmental implications associated with food system constraints (Question 14).

6. What impact does livestock grazing have on important biodiversity habitats?

Context

The question of whether livestock are necessary to maintain vital biodiversity habitats is part of a wider debate about the preservation of farmland ecosystems that have been shaped by centuries of agricultural practices. It prompts considerations about the ecological roles of livestock in supporting certain habitats, the potential consequences of altering agricultural landscapes, and the trade-offs between agricultural production and biodiversity enhancement.

The idea that livestock are indispensable for biodiversity maintenance is frequently presented as a well-established concept. Assertions such as "grazing enhances species biodiversity" or the notion that livestock can substitute for the ecological roles of extinct megafauna in sustaining ecosystem services, including healthy soils, water retention and biodiversity, are frequently encountered within discussions on land use and climate change. However, perspectives on this issue vary within the wider scientific discourse. Some scholars emphasise the importance of acknowledging that native forests in the UK generally harbour greater biodiversity than grassland landscapes. Conversely, others advocate for “conservation grazing”, promoting minimal livestock grazing to prevent tree encroachment on unique grassland habitats in selected areas.

Answer

Globally, humans and livestock have been the dominant land mammals for well over a century, while natural megafauna have experienced dramatic declines (Figure 5). The declines started during the pre-agricultural era of hunter-gatherers and were exacerbated by the latest glacial minimum (“ice age”) around 12,000 years ago, but the agricultural revolution that followed and the subsequent explosion of the human population have fundamentally changed the balance in favour of humans and livestock. The megafauna declines since 1900 have been particularly striking, with multiple species currently facing extinction. As a result, we have now entered the sixth mass extinction event in the Earth’s history, the first such event driven by humans.

The UK has a climate that is temperate with good distribution of precipitation across the seasons. When looking with a pre-civilisation historical view, this means that the UK would have been home to a mosaic of different habitats following the last ice age. These included temperate rainforest (estimated at around 20%, mostly along the West coast of Scotland, England and Wales), peatlands, wetlands and ancient grasslands (e.g. hay meadows). Whatever the natural state of the specific region, it would have been home to a vast number of species. Many of the ancient forests of the UK were subsequently cleared for a variety of purposes, including wood for building materials and farmland for crop production / livestock grazing. It is important to bear this historical context in mind when discussing the role of livestock in biodiversity improvements. As a result, there should be (and already are) movements towards having the least productive agricultural areas of the UK dedicated to nature recovery, and restoring these areas to their natural form.

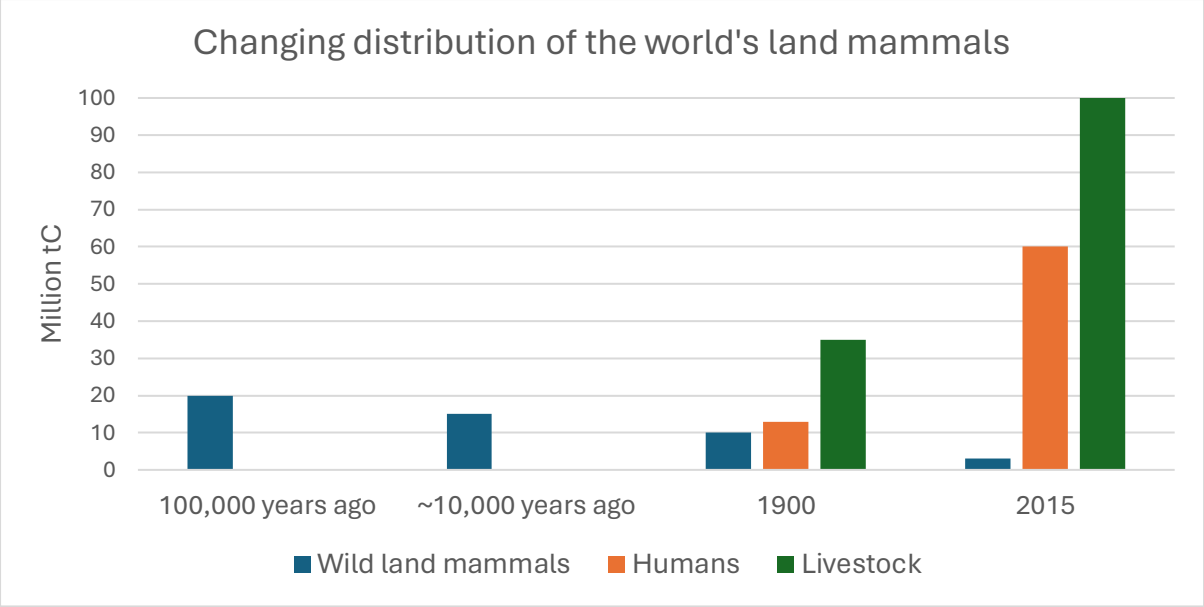

Figure 5. Estimates of the changing mass of wild land mammals, humans and livestock over time. By 1900, people and their farm animals were dominant, and in the years since then, the picture became even more extreme. Figure adapted from Our World in Data with long historical data from Barnosky (2008), 1900 data from Smil (2011), and 2015 data from Bar-On et al. (2018). https://ourworldindata.org/wild-mammals-birds-biomass

Regarding the natural grasslands of the UK, some of which are dedicated to grazing and others to arable farming, current conventional practices in agriculture – such as overuse of fertilisers and pesticides, and overgrazing[1] by livestock – can lead to significant biodiversity losses above and below ground. Fertilisers and pesticides have already decimated soil microbial life, insect / pollinator species, and aquatic life (through run-off). Widespread use of these chemicals has also put pressures on ground-nesting bird species and led to a loss of topsoil. Therefore, improving current agricultural practices is imperative from a biodiversity loss perspective.

As described earlier, in order to reduce the greenhouse gas emissions from the agricultural sector, it will be necessary for people to shift towards a diet that is predominantly plant-based and lower in meat and dairy. This will enable a more effective use of the remaining agricultural land (including grassland) following nature recovery. Unfortunately, even under the best conditions, purely arable farming still struggles to completely eradicate fertiliser and pesticide use (Question 7). Consequently, a reintegration of lower numbers of herbivores or composting into arable systems (mixed farming), in line with regenerative / agroecological principles, could represent a positive alternative to the conventional model from a biodiversity perspective (Question 3). Regenerative practices would also lead to healthier grasslands that are more resistant to flooding and droughts, and underlain by healthier soils. Furthermore, maintaining healthier grasslands along agroecological principles will help protect grassland birds, whether nesting in the UK or stopping here on their overseas migration routes.

[1] Here "overgrazing" means a situation where a plant that has been bitten severely in the growing season gets bitten severely again, forcing it to use energy from its crown, stem bases or roots to re-establish leaf. Generally, this results in the eventual death of the plant. In intermediate stages it results in reduced production from the plant, and commonly occurs in "set stock grazing" (continuous grazing) settings.

Evidence

- The arguments quoted in the context section above, to highlight the counter-arguments often encountered in the debates around livestock farming and climate, are from a 2021 web article by NatWest. While the article endeavours to counter prevailing narratives regarding the environmental impact of meat production and grazing, its reliance on anecdotal accounts and industry perspectives detracts from its credibility and limits its contribution to informed discourse on sustainable land management practices.
- Journal articles, including the work by Thompson et al. (2023), referenced as an example in the context section, contribute to the ongoing discourse on the ecological roles of livestock in land management. While Thompson et al. suggest that livestock can substitute for the ecological functions of extinct megafauna, our examination of changing land biomass distribution challenges this perspective. We argue that such assertions may overlook the significant negative impacts of animal agriculture on GHG emissions and land use at a systemic global level. Moreover, the prevalence of livestock biomass in contemporary ecosystems far surpasses that of historic megafauna. This highlights the need for a nuanced understanding of the complex interactions between human activities, contemporary ecosystems, and the historic context of the landscape, in shaping present-day environments.
- The historic development of land mammal mass, encompassing wild mammals, humans, and livestock, is exemplified in various publications. For instance, Barnosky (2008) examines long-ago historical trends, Smil (2011) delves into human impacts from the 20th century onwards, while Bar-On et al. (2018) provide contemporary insights into biomass distribution.
- The aforementioned publications, along with Zhang et al. (2022) and Hristov (2012), form the foundation for exploring the mass extinction of historic megafauna and wild mammal species that remain under threat as a result of human activities, including agricultural land expansion. These papers also shed light on the subsequent dominance of land mammal biomass by livestock, leading to heightened methane emissions and biodiversity losses.
- Barnosky et al. (2011) demonstrate that human activities, particularly our use of land for agriculture, have resulted in the sixth mass extinction event in the Earth's history.
- In general, more species diversity and richness are found in native UK forests than in grasslands. See e.g. Warner et al. (2021), Douglas et al. (2020), Alison et al. (2022), and Bunce et al. (2014).
- Newton (2013) and Sartorello et al. (2020) show that overgrazing contributes to biodiversity degradation, including in countries like the UK.
- For the detrimental effects of fertiliser and pesticide usage on biodiversity, including soil microbial life, pollinators, and aquatic ecosystems affected by run-off, see e.g. Nath et al. (2023), Sponsler et al. (2019), and Pericherla, Karnena & Vara (2020).
- When considering the safeguarding of various native bird species, it's crucial to recognise that many of these birds migrate, exposing them to the ever-increasing impacts of climate change both on their migration routes outside Europe and in their European grassland habitats. Prioritising the mitigation of GHG emissions, including those arising from livestock agriculture, is becoming paramount in safeguarding these species. See e.g. Howard et al. (2020a) and Schils et al. (2020).

- For arguments surrounding the debate on conservation grazing in the UK see e.g. Jordon et al. (2024), Lyons et al. (2017), Tälle et al. (2015), Jofré & Reading (2012), and Reading & Jofré (2015).
- While some species can adapt well to farmland habitats and rely on them for survival, as demonstrated by Brambilla et al. (2010), it's important to recognise that measures aimed at enhancing farmland biodiversity may not universally benefit all grassland-adapted species, as shown by Wilson, Vickery & Pendlebury (2007). Furthermore, Fuller (2000) notes that the decline in farmland specialist species is linked not only to land use change and abandonment, but also to the intensification of British farming.

7. What is the current environmental impact of arable farming, and how does it compare to livestock grazing?

Context

This is a question that is raised because of the common over-reliance of arable farming on inputs such as fertilisers and pesticides, prompting the suggestion that grazing livestock could offer a viable alternative. Answering it requires careful considerations about the sustainability of various farming methods and their implications for environmental stewardship. Additionally, there may be misunderstandings or misconceptions about the relative environmental performance of arable farming compared to livestock grazing, highlighting the need for evidence-based assessments to inform agricultural policy and practices.

The debate surrounding this question is often simplified into an either/or debate between arable or livestock farming, whereas the overall picture is far more complex. Although intensive arable farming can be intrusive and damaging to nature, arguments promoting livestock as an alternative often overlook their significantly higher land requirements in terms of per-hectare nutritional / calorific returns for humans. In addition, very few types of livestock rely solely on grazing, highlighting the interconnectedness of land use in both farming systems and leading to what is known as “ghost acres” – land that is required for growing grain on other farmland (in the UK or abroad) for the purpose of feeding livestock.

Answer

Intensive and exclusively arable farming can damage the environment in multiple ways, including:

- Depletion of biodiversity above (insect life) and below (bacterial / fungal communities) ground through over-use of pesticides and fertilisers;
- Degradation of topsoil through mechanical (reseeding, harvesting, tilling) and chemical (applying synthetic fertilisers and pesticides) disturbances, and resulting carbon emissions;
- Soil compaction by heavy machinery;
- Water pollution from fertiliser run-off;
- GHG (nitrous oxide) emissions through use of fertilisers.

Even the most environmentally conscious arable farms (i.e. those following regenerative agriculture / agroecological principles; see Question 3) struggle to eliminate the use of fertilisers and pesticides, as most arable crops are “annual” varieties (rather than perennial) and therefore require reseeding every year. Cover cropping and mixed rotations of nitrogen-fixing species such as legumes can help reduce the requirements for fertilisers and pesticides, even though it is difficult to eliminate them altogether.

Nevertheless, growing human-edible crops for humans to eat requires much less land to deliver the same nutritional value than converting animal feed to human food via grain-fed livestock. Here it is important to distinguish that in the UK a lot of ruminants (i.e. cattle and sheep) are fed

mostly on grass, hay, silage and a few concentrates (indigestible to humans), whereas most of the arable feed going into livestock provides inputs for intensive production of dairy cattle, pigs and poultry. UK livestock are also given feed containing imported soy and palm kernels which cause environmental issues overseas, predominantly in South America. Currently, more UK arable land is used to grow crops for animal feed than for human consumption. Pasture-fed livestock also often require housing for part of the winter season (due to weather / reduction in fodder quality / yield), although they tend to be fed on silage or hay when housed and do not use up land from arable farming directly. In general, a reduction in animal production in the current UK farming system can reduce the damage caused, both in the UK and overseas, by intensive arable farming to produce animal feeds.

In order to effectively tackle the joint climate and ecological emergencies, we must acknowledge both the damage done by intensive arable farming and the large land use requirements and methane emissions associated with livestock. A comprehensive solution will involve using as many techniques as possible to improve arable farming practices including low- or no-tillage, cover cropping, leys with nitrogen fixers, reducing fertiliser dependency, and growing perennial crops wherever possible. This switch from intensive arable farming will likely lower yields, but combined with a reduction of livestock numbers the net change in land use areas would allow substantial afforestation and peat restoration opportunities as part of nature recovery projects. One key benefit of reducing livestock numbers is the combined effect of curbing methane emissions and freeing up land for higher levels of carbon sequestration. It is worth mentioning that where grazing livestock are integrated into mixed farming systems (i.e. growing arable crops), the fertiliser potential of their manure can eliminate synthetic fertiliser inputs, and therefore support crop production while reducing the negative environmental impacts of intensive and exclusive arable farming.

Evidence

- As Jordan et al. (2024) highlight, the tillage of grassland (grazed or otherwise) when converting it to cropland can lead to significant losses in soil carbon. However, they also note that overgrazing can lead to similar soil degradation.
- For a more detailed exploration of the effect of intensive arable agriculture on soil health and carbon sequestration in the UK, see Muhammed et al. (2018) and Janes-Bassett et al. (2021).
- Benton, Vickery, & Wilson (2003) demonstrate that agricultural intensification can lead to declines in farmland biodiversity.
- For arguments showing the inefficiency of converting feed to food via livestock, see, for example, Alexander et al. (2017), Shepon et al. (2018), Xu et al. (2021), and Berners-Lee et al. (2018).
- Figures on UK land use dedicated to livestock production, sourced from de Ruiter et al. (2017), indicate that over 70% of all land in the UK is used for agricultural production. Within this, 63% is dedicated to livestock, with an additional 22% allocated to growing hay and crops for animal feed, leaving only 15% for growing crops directly for human consumption. The practice of additional feed for grazing animals, including supplementary feed in winter, is also noted in research by Garnett et al. (2017) and data from the Cattle Farming Practices Survey conducted by DEFRA in 2019.

- For evidence of the benefits and limitations of improving arable farming practices (such as low- or no-tillage, cover cropping, nitrogen-fixing ley systems, reducing fertiliser dependency, and prioritising perennial crops), leading to more sustainable food production overall but potentially lower yields, see e.g. Jordon et al. (2024), Nouri et al. (2019), Flohr et al. (2024), Schlautman et al. (2021), Menegat, Ledo & Tirado (2022), and MacLaren et al. (2022).
- For an in-depth exploration of the potential benefits of decreasing livestock numbers and separating feed production from arable land, allowing for the restoration of natural habitats to counterbalance arable farming impacts, refer to sources such as WWF (2022), Ritchie (2021), Shrubsole & Gordon-Smith (2020), and Climate Change Committee (2020b).

8. How does pasture-fed cattle compare with intensively farmed cattle from an environmental perspective, and at what numbers is it sustainable?

Context

This question is among the most frequently raised, and it often stimulates passionate arguments for/against various approaches. It is also an important one to discuss, as beef production in its current form is a significant contributor to GHG emissions and land use change, and therefore solutions are urgently needed to address this problem while ensuring the long-term sustainability of food systems. The potential differences in environmental performance between pasture-fed and intensive farming methods are often brought up in this context, as well as how much the overall head of cattle will have to reduce over the coming years.

The debate surrounding sustainable cattle farming encompasses contrasting viewpoints on the environmental impacts of extensive, grass-fed, organic (or regenerative) farming versus intensive farming methods. Advocates of extensive organic/regenerative farming argue that it promotes biodiversity, reduces inputs such as pesticides and antibiotics, minimises reliance on industrial fertilisers, enhances soil carbon sequestration, and reduces grain-feeding from land that could be used to grow crops for direct human consumption. On the other hand, proponents of intensive beef farming suggest that faster growth and shorter lifespans can lead to lower GHG emissions per kilogram of product, and that this approach takes up less land than extensive grazing operations. Ultimately, it is important to discuss the trade-offs between extensive organic / regenerative and intensive beef farming methods, and the levels at which these are sustainable both from a GHG emissions perspective and a broader environmental perspective.

Answer

In addition to environmental considerations, the debate about pasture-fed and intensively farmed cattle also raises ethical questions around which form of rearing livestock is the “right” one. It also touches upon the cultural issues of having a free choice on diets, and the look and feel of the British countryside.

Focusing first on the environmental considerations (the question at hand): from a purely carbon emissions perspective, when considering the “best case” intensively farmed UK beef cattle (i.e. fed almost exclusively on UK-based fodder) compared with their pasture-fed counterparts, the pasture-fed cattle emit more methane due to their slower growth and longer lifespans. However, the climate impact of intensively farmed beef varies widely depending on the circumstances. This is often linked to the feed sourced to raise the livestock, which, if imported from foreign countries that are associated with rainforest clearing (so-called “ghost acres” of crops such as soya), can have a significant carbon footprint which far outstrips that of pasture-fed beef. As covered in several earlier questions, the soil sequestration potential of grazing livestock is currently an area of scientific debate, especially around its initial magnitudes following adoption of agroecological practices, as well as its tendency to equilibrate over time. In the near term, when taking this into account, grazing livestock is generally considered to be less carbon-intensive than intensively farmed beef. However, this effect will level out over time, so further carbon reductions will have

to be found. When considering imported beef, creating new land for the cattle themselves is also a big driver for deforestation in many countries, further increasing emissions from land-use change.

On a broader environmental front, which includes water cycling, soil health and grassland biodiversity, when herds are managed with adaptive multi-paddock (AMP) grazing, pasture-fed cattle is generally considered more beneficial than intensively reared cattle. The latter can lead to environmental harm of waterways through mismanagement of manure and over-use of fertilisers / pesticides in order to grow fodder. Furthermore, pasture-fed cattle also tends to be linked to better animal welfare, with lower rates of disease and therefore antibiotic usage. Based on the above, pasture-fed cattle are likely to be better for the environment than their intensively farmed counterparts.

However, in spite of pasture-fed cattle's co-benefits for the environment, when it comes to the overall numbers of beef cattle that are sustainable from a climate perspective as well as a land use perspective, there is general consensus that numbers must reduce in the coming years (Question 14). While pasture-fed cattle in the UK generally produce lower GHG emissions than beef produced in other countries, it remains more carbon emissions-intensive than almost any other food source. Over 50% of the UK's methane emissions and 7% of the UK's total GHG footprint come from livestock, primarily cattle (based on GWP_{100}; see Question 4 for further details on GWP metrics). Moreover, when net food imports are considered, livestock products consumed in the UK account for 85% of the UK's total agricultural land use footprint, both within the UK itself and overseas, and much of this land could be better repurposed, from the environmental and climate perspectives (Question 5). In summary, grass-fed beef cattle at controlled numbers can deliver environmental benefits in specific contexts (e.g. natural grasslands), but the overall headcount of cattle for meat production in the UK must reduce somewhat over the coming years in order to meet both carbon and land use targets.

There is a wide range of opinions about the level to which the cattle numbers should reduce, from no or only slight reductions to complete removal. Given the fact that reductions in numbers will have to be balanced with supporting farmers' livelihoods, and that public demand for beef would need to reduce over time (likely through awareness-raising, education and potentially taxation measures), it is likely that the sustainable number would be somewhere in the middle of these extremes. The UK's Sixth Carbon Budget and National Food Strategy reports propose reductions of 30-50% relative to present-day levels by 2050. The changes needed would represent a substantial challenge on multiple fronts and would require consensus between various parties, especially when it comes to overcoming vested interests in the current status quo, as well as supporting the farmers through the transition.

Evidence

- For some of the arguments on organic farming, see Neal et al. (2020) and Benton, Vickery, & Wilson (2003).
- For discussions around the ambiguity of terms like "organic" and "grass-fed" and how livestock feed varies over the year, see Garnett et al. (2017) and the Cattle Farming Practices Survey (DEFRA, 2019).

- Organic, grass-fed, extensive agriculture by its very nature has a larger land footprint than intensively farmed livestock. See e.g. de Ponti, Rijk & Ittersum (2012), Smith et al. (2019), Seufert, Ramankutty & Foley (2012), and Barbieri et al. (2021).
- The cited numbers on UK methane emissions are based on the Sixth Carbon Budget report by the UK's Climate Change Committee (2020b).
- Estimates of livestock's total contribution to the UK's carbon footprint are based on the National Statistics (DESNZ 2024).
- When comparing the per kilogram carbon footprint, meat from grass-fed herds is also more intensive because of lower yields. See e.g. Clark & Tilman (2017), Pieper, Michalke & Gaugler, and Tuomisto et al. (2012).
- Additionally, more nitrogen is lost per kilogram of meat, contributing to more nitrogen pollution overall. See e.g. Noll et al. (2020) and Chand (2020).
- Klopatek et al. (2022) and Balmford et al. (2018) show that intensive beef farming can result in less methane and lower total greenhouse gas emissions per kg of final product.
- For papers on how animal agriculture – including intensive farming practices – drives deforestation, see e.g. Curtis et al. (2018) and Pendrill et al. (2019).
- This article by Kim et al. (2020) highlights how, in the worst case, intensively farmed beef can have the highest carbon footprint of any food. Additionally, Poore & Nemecek (2018) demonstrate that intensively farmed beef still has a bigger carbon footprint than almost any other food source.
- For broader impacts and considerations around intensive beef farming, including water footprint and use of antibiotics, see Broom (2019) and this policy insights paper by the OECD (2016).
- Regarding the scale to which the beef cattle headcount should reduce, some sources such as the Food Farming and Countryside Commission (FFCC, 2021) advocate strongly for ruminants as a tool for grassland regeneration. The Farming for Change report therefore suggests a reduction of just 2.85% between 2017 levels (904,344 tonnes per annum) and 2050 modelled levels (878,559 tonnes per annum). It should be noted that this scenario also assumes the UK shifting from being a net importer of beef to a net exporter of beef, and therefore dietary intake of beef in the UK reduces from 1,120,000 tonnes per annum to 710,000 tonnes per annum (a 37% reduction).
- On the other hand, some strong critics of livestock farming, such as George Monbiot (2022) in his book Regenesis, advocate for a total elimination of livestock farming and replacement with precision fermentation for protein supply.
- For a more detailed breakdown of scenarios on dietary shifts and changes in the consumption of livestock products, see the UK's Sixth Carbon Budget and the National Food Strategy reports.

9. What is the environmental impact of imported meat when compared with locally produced meat?

Context

This question arises from concerns about the environmental impacts of food production, including GHG emissions and land use change. It is an important question to ask because it evaluates the environmental consequences of global food supply chains and can inform decisions regarding food consumption, as well as influencing national policies.

The debate centres on comparing the environmental impact of locally produced meat versus imported meat. Advocates highlight the lower carbon footprint of UK-produced meat, and caution against exporting carbon emissions abroad to meet livestock product demands. However, solely focusing on the origin of meat overlooks the broader issue of unsustainable food systems and dietary patterns (Question 14). The potential of dietary shifts towards more plant-based options, and the associated global benefits of reduced meat and dairy consumption, are equally worth considering as part of the debate.

Answer

It is true that meat produced in the UK can be significantly less carbon-intensive than in other parts of the world. For example, beef produced in the UK has, on average, around a third of the emissions of global average beef (based on the GWP_{100} metric). It's worth highlighting here that the type of meat and context is important. Beef and lamb meat produced in the UK typically has a significantly lower footprint than imported equivalents. However, although UK cattle as well as sheep are predominantly pasture-fed, they often receive feed supplements. These usually contain soy and palm kernel, which can come from deforested regions overseas. In the case of pork and poultry, the footprint will very much depend on the source of the feedstock. For instance, if Brazilian soya from deforested areas is the main feed for chickens being produced in the UK or Spain, the resulting footprint will be dominated by the deforestation and won't be much different between the two European countries, except from relatively small variations in transportation emissions to the end consumer.

UK beef and other locally produced meats are sometimes presented as more sustainable alternatives that could be exported in order to reduce global emissions from the meat industry. However, it is highly unlikely that exporting meat would benefit subsistence agriculture communities that rely on livestock for vital nutrients and other resources. Instead, it would perpetuate the reliance on meat-based diets in importing countries, many of which would benefit from reducing their per capita meat consumption.

Even in the UK, meat is more carbon-intensive and requires considerably more land than almost all plant-based alternatives. While it would generally be worse to import meat than produce it locally, it would be better still to reduce meat consumption and replace some of it with plant-based options. We share a collective responsibility to reduce all GHG emissions as quickly as possible to avoid triggering climate tipping points and causing more catastrophic climate damage. We also have responsibility to reverse biodiversity losses in the UK and worldwide. Any

such transition must, of course, be carried out in a way that supports and protects the livelihoods of farmers and their communities by providing alternative income streams (Question 2).

While the discussion above focuses specifically on the environmental footprint of imported vs. locally produced meat, it is also worth commenting on the wider benefits of locally produced meat, especially from animal welfare perspectives. The UK's farming community has carried out positive and effective lobbying of the UK Government since Brexit to ensure that the existing quality and welfare standards are not watered down by new international trade deals, which looked a very real possibility judging from initial drafts. At the time of writing, UK standards have been generally preserved (e.g. around hormone treatment, chlorinated chicken, and inhumane treatment of animals), which is important from an ethical perspective as well as to ensure fairness for UK farmers who are being held to these high welfare standards.

Evidence

- Sources that examine the higher carbon emissions from imported meat include publications by the Climate Change Committee (2020a), Poore & Nemecek (2018), and Revoredo-Giha & Costa-Font (2021) on the link between livestock feed and deforestation.
- Therefore, the cautionary note regarding the potential export of livestock emissions abroad, as articulated in the 2020 CIEL report and reiterated in the contextual section, is warranted. However, it is important not to use this as justification for maintaining current practices within UK farming. Instead, this should prompt a reduction in livestock numbers, aligning with the dietary changes recommended in initiatives such as the National Food Strategy – a perspective also supported by the aforementioned CIEL report.
- There is plenty of evidence that vegan, vegetarian or low-meat diets could significantly reduce global emissions from the agricultural sector, and that such a shift will likely be part of sustainable food systems in the future. See e.g. Kozicka et al. (2023), Hedenus, Wirsenius, & Johansson (2014), Costa et al. (2022), Chen et al. (2022), Barthelmie (2022), Chan et al. (2022), and Springmann et al. (2018).
- In their policy recommendations, Jordon et al. (2024) appear to imply that UK livestock numbers might not need to be reduced, as exports could help make meat consumption more sustainable elsewhere. They also caution against the risk of shifting emissions to other countries if reducing domestic meat production leads to an increase in meat imports. The risk of displacing production within the UK's own food system can be mitigated by corresponding dietary shifts. It therefore appears that dietary shifts, as a lever to manage a transition within the UK livestock sector, have been inadequately considered in the construction of this argument. Meanwhile, as highlighted in the text above, exporting UK beef is likely to do very little for overall emissions reductions. One of the main reasons for keeping some meat in the global food system is the provision of vital nutrients to remote communities reliant on subsistence agriculture for a balanced diet. It does not seem realistic or affordable for such communities to purchase UK beef. Any country that can afford such "sustainable" UK exports probably needs to make sizeable cuts in its own per capita consumption of livestock products and has its own livestock agriculture to manage in terms of emissions reduction. Simply swapping one source of emissions-intensive food (e.g. US beef) for another slightly less intensive source (UK beef) only delays the inevitable need for a just transition of our agricultural system and a reduction of livestock farming in the UK.

10. What impact does substituting dietary beef with chicken, pork or fish have on the environment?

Context

This question arises from concerns about the environmental impact and ethical considerations of beef production, as well as interest in comparing the environmental impacts and nutritional benefits of different dietary options.

When it comes to carbon emissions, it has been broadly publicised that beef is more carbon-intensive than chicken, pork and fish, and therefore the latter three are often proposed as more environmentally friendly choices (and better from a health perspective, too). However, this proposition over-simplifies what is, in fact, a complex and contextual picture. This includes the farming practices associated with intensive types of meat production (e.g. nitrogen run-off from poultry units and pig farms, leading to environmental damage). Additionally, concerns regarding animal welfare and overfishing of wild fish populations mean that the overall environmental and ethical impact and trade-offs need careful consideration. Finally, when considering all the food system issues holistically, the choice of one meat over another needs to be weighed up against the benefits of plant-based diets. This question therefore prompts a critical examination of dietary choices and their broader implications for sustainability.

Answer

Chickens and pigs are monogastric animals that do not ruminate, which means they do not emit methane from enteric fermentation, and therefore have smaller GHG footprints than beef or lamb per unit of human nutrition. Chicken generally has the lower greenhouse gas footprint of the two because chickens are smaller, require less feed, and have shorter lives than pigs. The GHG footprint of seafood varies depending on the type and method of production.

However, other environmental problems associated with chicken and pork need to be considered. Nitrogen run-off from poultry units and pig farms can cause major pollution; for example, ongoing run-off into the river Wye is devastating the local wildlife. While chicken tends to be the “best” meat in terms of GHG emissions, its footprint is still comparable to or higher than most plant-based alternatives. Furthermore, both chickens and pigs in the UK are often fed human-digestible crops, including soy that tends to be grown on deforested lands, and therefore farming these animals creates large indirect climate and ecological footprints. And although not necessarily an environmental issue, chickens in particular are often treated appallingly, with the live birds having very little light or space to move.

Regarding products of the sea, from a carbon perspective wild fish caught on a line can be a very low-carbon option, while farmed lobsters or crustaceans have a GHG footprint similar to lamb. However, from a broader environmental perspective, many wild fish populations are dangerously overfished, which is having a large impact on both freshwater and ocean biodiversity. Some of these already overfished populations are still being threatened, since they are used as feed for farmed fish. There is also evidence of farmed fish spreading disease to wild fish populations, where they wreak further havoc.

At this stage of the planetary polycrisis – encompassing climate change, biodiversity loss, and major disruption to the phosphorus and nitrogen cycles – we cannot rely on incremental improvements. So, rather than substituting one form of meat for another, a shift to predominantly plant-based diets will have the most significant (and necessary) positive impact on the environment.

Evidence

- Numerous sources, ranging from online platforms such as the Mossy Earth blog to scholarly articles like Caro et al. (2016), underscore the emissions intensity associated with beef consumption. They highlight this to advocate for dietary shifts away from beef towards less emissions-intensive meat types, as a potential strategy for mitigating global emissions from the livestock sector. However, as we hope is clear from the answer above, merely substituting one meat type for another is not enough to mitigate the climate impact of livestock agriculture. Effective mitigation requires more urgent and comprehensive solutions.
- For a general overview of feed sources and welfare for pigs, see the RSPCA website. The RSPCA also offers a good overview on how chickens are kept, which can serve as a basis for discussion of welfare concerns.
- Intensive poultry farming has negative impacts on the environment and on human health Gržinić et al. (2023), with awareness raised recently of the devastation of UK rivers Withers et al. (2022).
- For a breakdown of the global feed supply network and its impacts on land use change see e.g. Sporchia et al. (2023), who highlight the displacement of human edible crops and deforestation associated with the growing demand for poultry, and therefore chicken feed including palm oil and soybeans.
- A report by The Landworkers' Alliance, Pasture for Life, Sustain and Hodmedod (2023), for example, highlights the urgent need to reduce soy demand in the UK, given its prevalent use in pig and poultry feed. Balancing sustainability in feed production and crops for human consumption would require a substantial reduction of over 80% in pig and poultry production, as outlined in one of the report's scenarios. This proposed shift entails a change in dietary habits, promoting increased consumption of pulses while decreasing the intake of pork and chicken. Importantly, such a transformation presents opportunities for small and medium-scale farmers in the pig, poultry, and legume sectors to take on more significant roles, fostering resilient and ethically focused farming businesses.
- For evidence surrounding overfishing, issues with some of the common aquacultural practices and subsequent biodiversity impacts, see e.g. Dulvy et al. (2021), Sala et al. (2021), FAO (2019), Jiang et al. (2022), Bouwmeester et al. (2020), Vollset et al. (2021), and Mordecai et al. (2021).

11. What impact will any reduction in livestock production have on food security?

Context

The question of whether reducing livestock production will cause food insecurity is important to raise because it is often argued that livestock products are crucial for many diets worldwide, and any significant reduction could lead to food shortages and nutritional deficiencies. However, the debate around this question also underscores broader sustainability considerations and inequalities within the global food system that need to be addressed.

As highlighted in Question 14, some suggest that population growth necessitates an expansion of animal agriculture to meet increasing food demands. The Dublin Declaration, for instance, advocates for increasing the availability of livestock-derived foods to address the nutritional needs of billions of people worldwide. Proponents of these arguments assert that meat remains an essential source of nutrients, especially in regions where alternative food sources are limited.

However, the role of meat in the global food system is subject to debate. While it may be essential in certain contexts to address nutritional deficiencies, the current reliance on animal agriculture comes with significant environmental and ethical implications. For instance, a substantial amount of arable land is allocated to growing livestock feed, raising concerns about inefficiencies in food production and the potential for reallocating these resources to more sustainable and equitable food production methods, while also returning some farmland to a more natural state through nature recovery programmes.

Answer

Clearly, there is a need for solutions that mitigate emissions from our food system in ways that do not threaten global food security. Meat and dairy will still likely play some role in the global food system, especially in regions where other food and nutrient sources are limited. However, in most countries, reducing livestock production would actually increase food security, especially in places like the UK where production is disproportionately and unnecessarily high in relation to the population's calorific and nutritional needs. This is because livestock require a vast amount of land and feed supplements compared to producing crops and vegetables. In the UK, for example, over 70% of all land is used for agricultural production. Of this, 63% is dedicated to livestock, 22% is used for growing hay and crops to feed livestock, and only 15% is used for growing crops for human consumption. Despite requiring so much land and feed, livestock only produce one third of the UK's calories and less than half its protein, making this kind of farming an inefficient way of feeding the population. Furthermore, the UK currently meets around 40% of its food demand by economic value through imports, making it vulnerable to any shocks to the global food system.

With reduced levels of meat and dairy consumption, more land would be available to grow food for people, since human-digestible crops require significantly less land and other resources to deliver the same final nutrient content as meat and other animal products. This would help reduce the UK's imports and make it more self-sufficient, thus increasing UK food security.

Alternatively, if the land freed up from reduced levels of meat and dairy production is not suitable for growing crops, it can instead be restored to a more natural state (see Question 5), thus improving its biodiversity and increasing carbon sequestration. This also improves long-term food security by mitigating against more extreme climate impacts and further biodiversity losses that would negatively affect food production in the future.

Evidence

- The full Dublin Declaration, presented here as an exemplar of advocating for the purported nutritional indispensability of meat consumption, was published in Animal Frontiers in 2023.
- Figures on UK land use dedicated to livestock production are based on de Ruiter et al. (2017).
- DEFRA (2021) statistics show that the UK currently meets around 40% of its food demand through imports.
- Especially in the UK context, meat is currently overconsumed, and reducing this consumption could not only relieve pressures on the environment but also help a transition toward healthier diets. See e.g. Springmann et al. (2018) and Willett et al. (2019).
- Doelman et al. (2019) conclude that lower meat consumption could assist with attaining mitigation targets, while avoiding negative impacts on food security in high- and middle-income regions by reducing the demand for land.
- For arguments on the inefficiency of feeding human-consumable crops to animals, see, for example, Alexander et al. (2017), Shepon et al. (2018), Xu et al. (2021), and Berners-Lee et al. (2018).
- There are also parts of the world where meat consumption will likely remain an important part of rural subsistence agriculture to maintain food security. However, it is important to highlight that these are highly particular situations, and evidence supporting such needs should not be extrapolated to apply broadly to the global population. See e.g. Nunes et al. (2019) and Thronton & Herrero (2015).

12. What role can technology play in reducing farming emissions?

Context

Given the imperative to mitigate the environmental impact of agriculture, particularly livestock's substantial contribution to climate heating and land use change (Question 14), the question about the role that technological solutions can play in reducing farming emissions warrants attention. This question is rooted in the broader goal of reducing the ecological footprint of agricultural practices while ensuring the long-term sustainability of food systems.

Various technological interventions have been proposed to facilitate the UK farming sector's transition to Net Zero emissions. The most prominent of these from a carbon perspective are methane blockers, which aim to reduce methane emissions from livestock by altering the animals' digestive processes. Equally important are genetic modifications, focusing on breeding livestock with traits that decrease methane emissions while enhancing meat productivity. These are in addition to mechanical interventions for arable farming, such as seed drills that minimise soil disturbance (and therefore reduce carbon emissions compared to conventional cultivation), low-carbon machinery (e.g. electric quad bikes), and low-carbon energy generation/storage (e.g. solar, wind and anaerobic digestion electricity generation paired with battery technology). Indoor horticulture and vertical urban farming are other options being considered to reduce pressure on land (Question 13). Finally, various AI technologies are being introduced into agriculture to reduce high-carbon inputs, reduce negative environmental impacts, and improve productivity. These include measurements from drones, other forms of remote sensing, machine learning algorithms to analyse the data, and robotics.

Answer

Many of the proposed technological interventions, particularly those seeking to reduce methane emitted by livestock, are currently shrouded in uncertainty regarding their potential to be scaled up and actually reduce GHG emissions. For further exploration of non-livestock technical interventions, particularly indoor and vertical farming solutions, please refer to Question 13.

While breeding programmes offer the ability to improve overall health and efficiency in dairy and beef production, a more targeted approach focuses on selecting animals with lower methane emissions. This low-methane breeding strategy has the potential to deliver a 0.15% annual decrease in emissions. However, even with widespread adoption, the Sixth Carbon Budget estimates an overall abatement potential of just 8% from livestock breeding. Nutritional interventions offer another avenue for reducing methane emissions. Feeding strategies like high-sugar-content grasses and high-starch diets for dairy cattle show promise. It's important to note, however, that the effectiveness of these dietary changes might not be fully additive with other methods, potentially leading to an overestimation of their combined impact.

NH4 inhibitors, including chemical inhibitors like 3NOP, along with vaccines, are emerging technologies with the potential to significantly reduce methane production in livestock. However, their scalability and real-world effectiveness remain uncertain. While modelling suggests a 30% annual abatement potential under ideal circumstances, achieving this level of reduction hinges on overcoming these uncertainties. Precision feeding, which tailors feed intake to individual

animal needs, also offers potential benefits by improving feed conversion ratios. The Sixth Carbon Budget projects that a high uptake of combined dietary interventions could achieve an abatement potential of up to 36% by 2035. However, a critical limitation exists: most of these nutritional interventions are currently only suitable for housed livestock, where controlled implementation is easier. This disparity creates a significant difference in potential uptake between dairy herds (primarily housed) and beef herds (more often grazing).

As things stand, existing limitations and uncertainties associated with these emerging technologies to reduce methane emissions from livestock mean that implementing these measures, which are solely supply-side, will not be enough to reach Net Zero without a parallel reduction in demand-side consumption of meat and dairy (Questions 14 and 4). Humanity's ongoing failure to start delivering the GHG emission reductions required to limit global warming to 1.5°C with little or no overshoot means that when there are multiple ways to reduce emissions, we often need to use them all. Relying solely on technological fixes for livestock farming may divert attention from broader systemic changes needed to address the root causes of emissions, such as dietary shifts towards more plant-based options.

An over-reliance on technological measures, many of which have yet to be tested at scale, is also a highly risky strategy with significant ethical implications, since if these measures don't work at the intended scale, or don't perform as well as is hoped, the result will be large quantities of unabated emissions. As a general principle, future promises should not be used to excuse real current harms. In addition, an excessive shift towards technology, if not carried out ethically, can disempower farmers and growers, if the technology is so sophisticated that the inherent skill of farmers is put into the hands of the technology companies, rather than within their own power to act.

Additionally, planning only incremental changes to current practices assumes that the status quo will broadly remain in place. We know that to tackle all aspects of the current "polycrisis", including biodiversity loss, soil erosion, water pollution, and disrupted nitrogen and phosphorus cycles, there will need to be systemic changes to the farming system. These changes could mean that the technological solutions proposed originally are less relevant by the time they are introduced.

Thus, while technological interventions offer potential pathways towards reducing emissions in the farming sector, they do not provide a comprehensive solution without accompanying policy, behavioural, and other systemic changes.

Evidence

- A study conducted by Cowley et al. (2023) aimed to investigate the effectiveness of using seaweed-based feed supplements to reduce methane emissions in Wagyu cattle. The results of the study were mixed as the supplements were found to reduce methane production but also lowered the overall feed intake, resulting in reduced liveweight gain. Consequently, there were no significant changes in methane intensity.
- Voget-Kleschin et al. (2024) discuss the ethics of carbon removal. They point out that carbon capture is often promoted as a quick-fix solution by industries and policymakers, which can divert attention away from the systemic changes that are truly required.

Furthermore, carbon removal itself can cause significant harm, and therefore, rather than relying solely on this approach, we should work towards bringing about societal changes that have the potential to significantly reduce emissions without the same negative ethical implications.

- Heck et al. (2018) critically examine the concept of Bioenergy with Carbon Capture and Storage (BECCS) in the context of planetary boundaries. The paper highlights that the scale of BECCS, assumed to be theoretically available by organisations like the IPCC, would necessitate vast amounts of land. Deploying BECCS on such a large scale could have severe consequences for biodiversity and food security. The authors argue that while BECCS has been touted as a potential solution to climate change, its implementation must be carefully assessed to avoid exacerbating other environmental and societal challenges.
- While the carbon capture and storage (CCS) in BECCS is widely assumed to be ready or nearly ready for deployment at scale, it has a long history of failures, as showcased by Abdulla et al. (2021).
- Numerous publications and policy reports discuss the potential of current technological solutions to help the agricultural sector achieve Net Zero emissions. However, there is considerable disagreement regarding whether strategies such as increasing productivity, altering land management practices, and implementing BECCS, among other measures, are sufficient to completely reduce and offset emissions. While the National Farmers' Union (NFU 2019) expresses optimism about achieving their 2040 Net Zero target, CIEL (2023) points out significant gaps between the necessary emission reduction scenarios for agriculture aligned with the UK Government's Net Zero goal (e.g. those proposed as part of the Sixth Carbon Budget), and the current state of technological and management solutions. Many of these publications, including Capper (2020), share a common emphasis on maintaining farm profitability within the existing agricultural policy framework. Consequently, they tend to favour and prioritise minor adjustments that offer limited potential for substantial change. Often, the broader environmental context and the imperative for meaningful action to address the climate and ecological emergencies are not fully considered in these discussions. As underscored by Lamb et al. (2016), relying solely on technological advancements is insufficient. Any mitigation strategies for land-based emissions rooted in technological interventions must be accompanied by systemic, societal, and behavioural changes, including a reduction in meat consumption.
- The Scottish Rural College (2020) was contracted to provide the underlying report on the potential for non-CO_2 abatement in the agricultural sector that informs the Sixth Carbon Budget.

13. What role do indoor horticulture and vertical farming play in shaping the future of food production and its environmental impact?

Context

Indoor horticulture involves the cultivation of plants within controlled environments, employing techniques such as artificial lighting, temperature regulation, and soilless cultivation to optimise growing conditions. A prime example of this innovative practice is vertical farming, which utilises artificial lighting to replace solar radiation, providing a consistent and precise spectrum of light required for plant growth and development throughout the year, regardless of seasonal weather variations. Vertical farms predominantly cultivate low-biomass crops, such as leafy greens, herbs, and small fruits and vegetables. These crops are typically grown in soilless systems such as hydroponics, aeroponics, or aquaponics, vertically stacked in multiple columns.

Therefore, the question of the role of indoor horticulture and vertical farming in shaping the future of food production and its environmental impact is important because of their potential to address the escalating need for food production, which exacerbates the strain on already limited land resources, while also maximising food yield. Since the global population is projected to increase to nearly 10 billion by 2050 according to the UN, the need to implement farming approaches that alleviate the increasing pressure on food production is becoming increasingly urgent. Countries like the United States, Germany, the Netherlands, China and Japan have adopted vertical farming, with the Netherlands standing out as a prime example. Despite facing land scarcity, the Netherlands was the world's second-largest exporter of agricultural products in 2022, demonstrating the potential of a combination of indoor farming methods such as the use of greenhouses and vertical farming, as well as "precision farming", for overcoming spatial constraints in food production. However, the adoption of indoor horticulture and vertical farming is not without its challenges. There is an ongoing debate on what can be done to significantly reduce their environmental impact, particularly concerning the energy demands of artificial lighting systems and high upfront costs.

Answer

Indoor horticulture and vertical farming are innovative methods that could offer promising solutions to meet the increasing demand for fresh food while minimising environmental degradation. Vertical farming stands out for its ability to alleviate pressure on land, reduce water usage, minimise food transportation distances, and decrease pesticide use, all while ensuring consistent quality of produce throughout the year. Additionally, studies have shown that food produced through indoor farming methods like vertical farming has several environmental benefits. It requires less fuel than conventional farming, leading to reduced CO_2 emissions, and significantly increases productivity (five to tenfold per unit land area) while reducing seasonality constraints (Figure 6).

However, it's important to acknowledge the challenges posed by indoor horticulture and vertical farming. Both approaches consume a significant amount of electricity due to the operation of controlled environments, including artificial lighting. Most studies already suggest that for controlled-environment technologies such as vertical farming to become a truly sustainable

solution, they need to transition towards using renewable electricity sources. Continued fossil fuel reliance for powering these systems would negate the environmental gains.

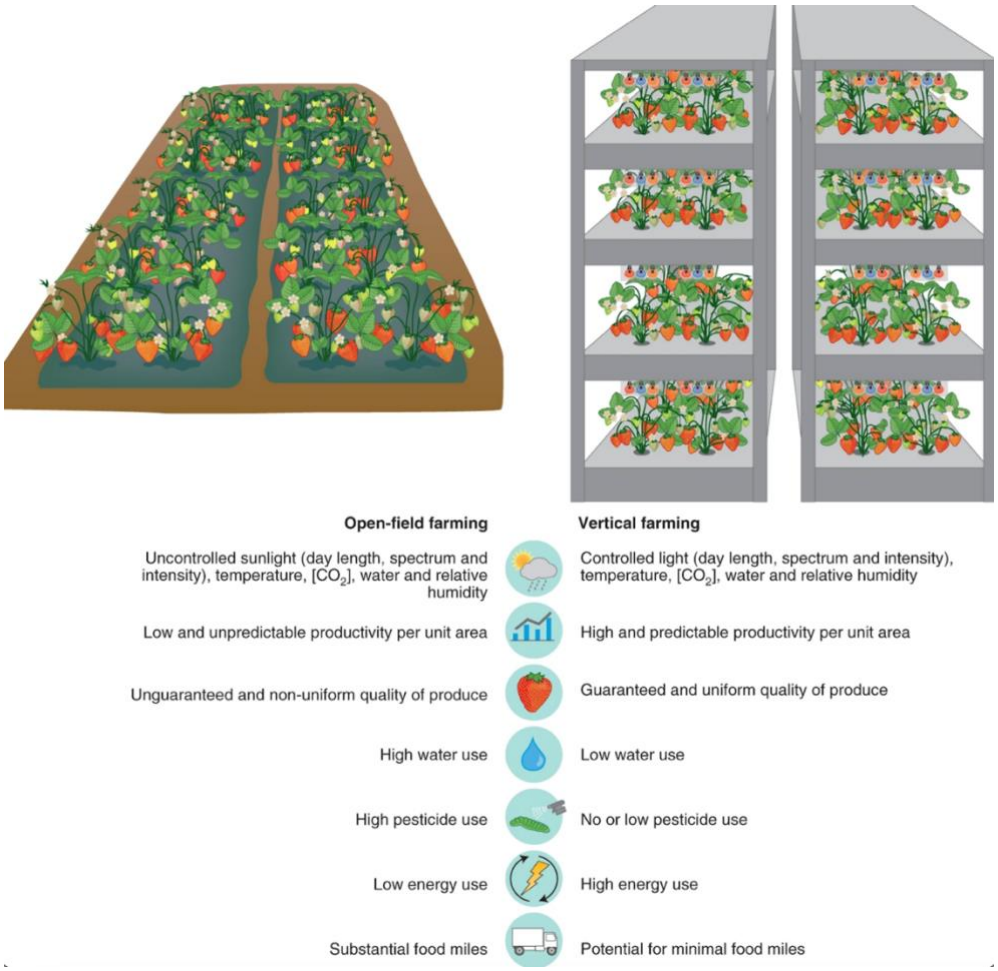

Figure 6. Key differences between open-field farming and vertical farming. Source: van Delden et al. (2021). Current status and future challenges in implementing and upscaling vertical farming systems. Nature Food, 2(12), 944-956. https://www.nature.com/articles/s43016-021-00402-w

Furthermore, there are limiting factors around scalability and entry costs. High initial investment costs create a barrier to entry, potentially limiting this technology to large corporations and hindering its widespread adoption for the time being. Additionally, only a limited variety of crops is currently suited to these innovative farming practices. These crops tend to be high-value, speciality crops rather than the staple crops needed to feed a growing global population. Therefore, in its current state, vertical farming and similar innovations are unlikely to be the sole solution for ensuring global food security. However, they can already play a valuable role as a complementary system, providing fresh, high-quality produce in urban areas and potentially serving niche markets for specific crops.

In conclusion, while controlled-environment agriculture technologies, including vertical farming, pose challenges in terms of energy demand and supply, startup costs and crop variety, they hold immense potential for the future. Continued innovation and development could see them become a valuable tool for small-scale subsistence farming and large-scale industrial farming alike. These technologies could also improve access to fresh, high-value produce in regions where traditional methods struggle to provide a nutritionally balanced plant-based diet. By

overcoming these hurdles, indoor horticulture and vertical farming can not only deliver on their promise of reduced environmental impacts associated with food production, but also become a significant contributor to global food security.

Evidence

- For global population projections, see Earth4All (2022) and the UN DESA (2022).
- For sources that look into challenges in implementing vertical farming, see Abdullah et al. (2021), Lubna et al. (2022) and van Delden et al. (2021).
- For discussions regarding the carbon footprint of vertical farming due to electricity usage for artificial lighting, compared to other conventional farming methods, see Blom et al. (2022).
- Sandison et al. (2022) investigated environmental impacts associated with vertical farming in comparison with conventional farming methods in Scotland – particularly, the role of electricity and renewable energy in the carbon footprint of both.
- Avgoustaki et al. (2023) explored the role of continuous and intermittent intervals of lighting operation in reducing the carbon footprint related to electricity consumption by vertical farming.
- For an overview of the historical developments and current status of vertical farming and similar technologies, including the role they could play in addressing different challenges such as food security, see Mitchell (2022).

14. How sustainable is the amount of meat and dairy in the current UK and global diets?

Context

Although the UK makes up a small proportion of the global population (0.84%) and an even smaller proportion of the habitable global land area (0.23%), it has global influence and leadership, and therefore the decisions made here can have a big impact around the world. The question about the sustainability of the current typical diet in the UK is essential in the face of global food insecurity and the climate and biodiversity crises, compounded by rising global population. The challenge is to design a future food system in a way that enables healthy and nutritious diets, while simultaneously addressing greenhouse gas emissions, biodiversity loss, land use issues and other environmental footprints.

Discussions around sustainable dietary changes often lead to arguments suggesting that population growth necessitates increased food production, or note the rising global meat consumption tied to emerging economies adopting the lifestyle choices of the Global North. Proponents of this perspective sometimes argue that maintaining current dietary habits, including increased levels of meat consumption, is essential for ensuring food security and supporting agricultural livelihoods. Further to this, some say that as emerging economies' GDP increases, the expansion of lifestyle choices will inevitably drive up meat consumption, thereby stimulating market dynamics to amplify the global livestock industry.

The counter-argument to this position is that current UK diets, which often include high levels of meat and dairy consumption, are not sustainable either globally or nationally. Advocates for reducing meat consumption in the UK and other developed nations cite not only meat's environmental impacts but also the established health benefits of a more plant-based diet compared to diets that are high in meat. They also state that promoting a shift towards more plant-based alternatives and locally sourced plant foods could enhance food system resilience and reduce environmental challenges associated with livestock farming.

Answer

The Global View

A look at the global perspective is useful before turning more specifically to the UK's diet. Figure 7 shows the current share of global land area for agriculture and how this relates to calorie/protein consumption. Importantly, this highlights that 50% of all global habitable land is currently farmed and 77% of this farmed land is used to support livestock, which only produces 18% of human supply of calories and 37% of human supply of protein.

Meanwhile, Figure 8 presents the global "food energy flow" in kilo-calories per person per day starting with the split of human-edible crops (e.g. grains – 5,935 kcal) and non-human edible crops (e.g. grass – 3,812 kcal), followed by the losses through the food supply chain via harvesting, distribution and livestock, to the eventual consumption by humans (2,531 kcal). A key point to note is that in human-edible crops alone we currently produce around 2.5 times the

calories needed to provide a healthy diet for all. In addition, even considering losses through the system, there would still be a small surplus in supply of required global calories from human-edible crops alone if the food were optimally distributed.

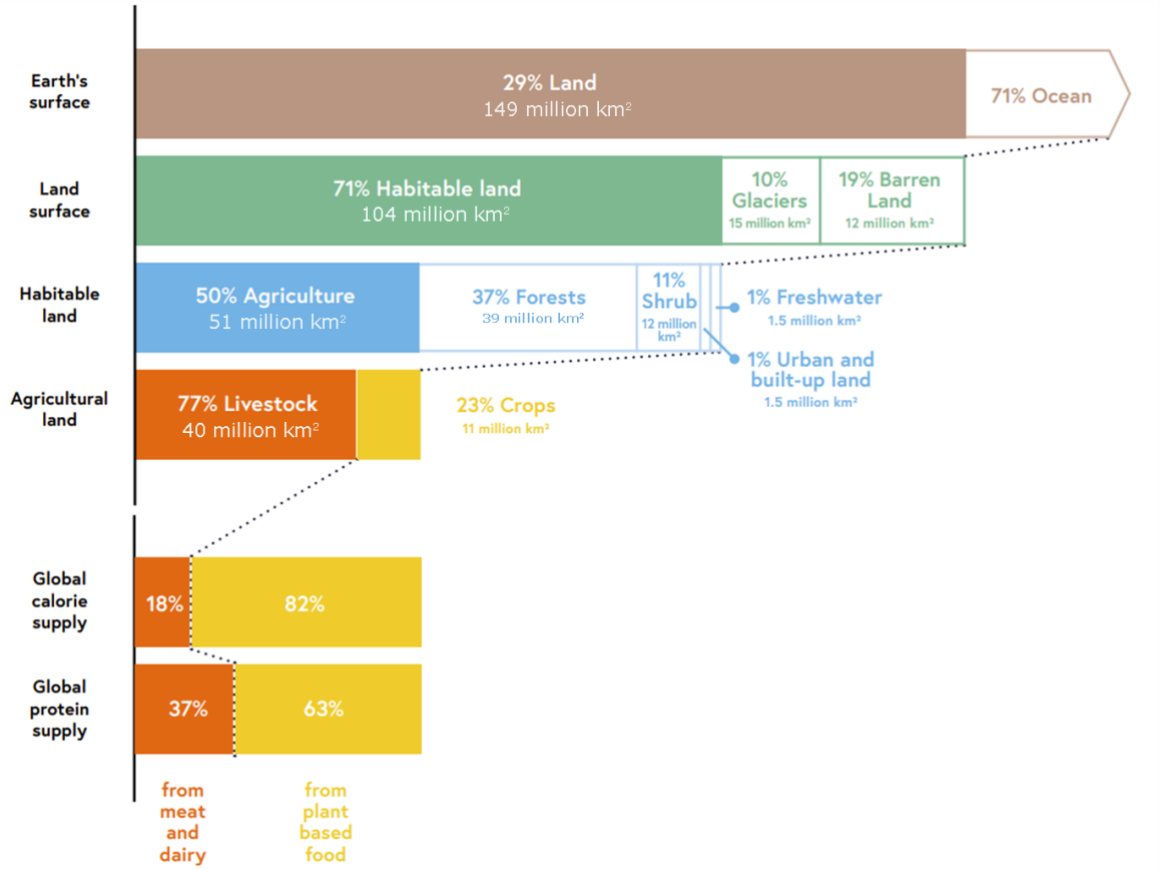

Figure 7. Current share of global land area for agriculture and how this relates to calorie/protein consumption. Source: Dimbleby et al. (2022) "National Food Strategy"; https://www.nationalfoodstrategy.org.

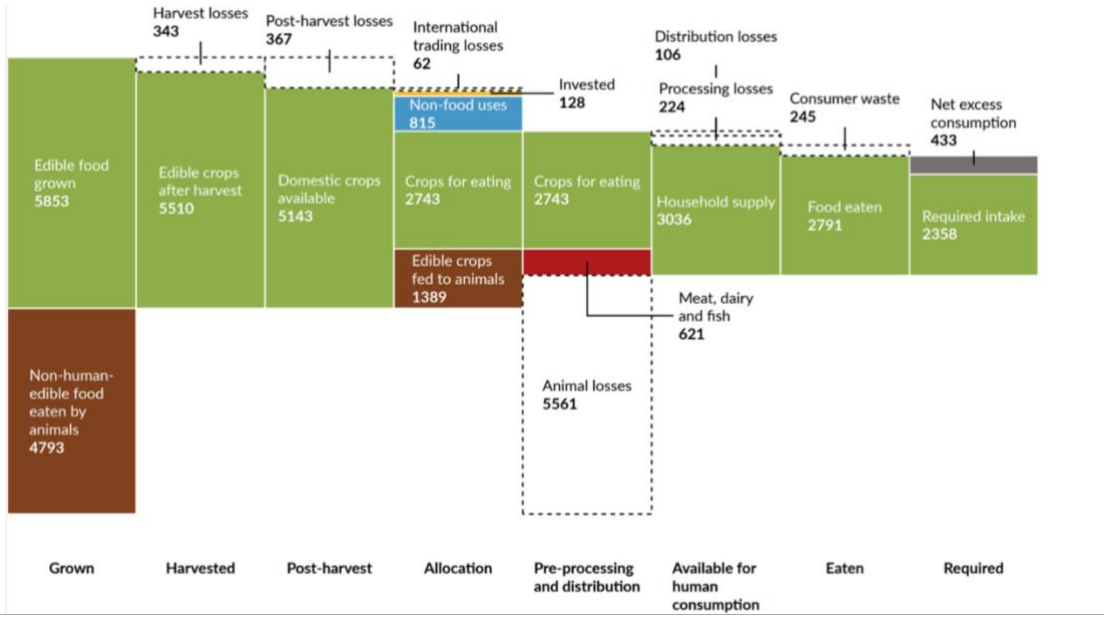

Figure 8. Global food energy flow in kilo-calories per person per day. Source: Berners-Lee et al. (2018); doi: https://doi.org/10.1525/elementa.310. Updated by Rosie Saxton and Tom Higgs in 2023 using more recent global data.

Taking this global perspective further still, Figure 9 (below) models different scenarios for calorie consumption based on today's global diet (the left-hand stacked bar, equivalent to the data presented in Figure 8) and projecting this forward to 2050 (the three right-hand stacked bars) when global population is expected to reach nearly 10 billion. These scenarios involve different combinations of the following measures:

- No human-digestible crops fed to animals
- Eliminate excess consumption (while ensuring food is distributed equitably)
- Eliminate food waste
- Cease biofuel production
- Reduce consumption of meat and dairy

Crucially, all the scenarios assume no further increases in global agricultural land beyond its current share of the total habitable land (50%, as in Figure 7).

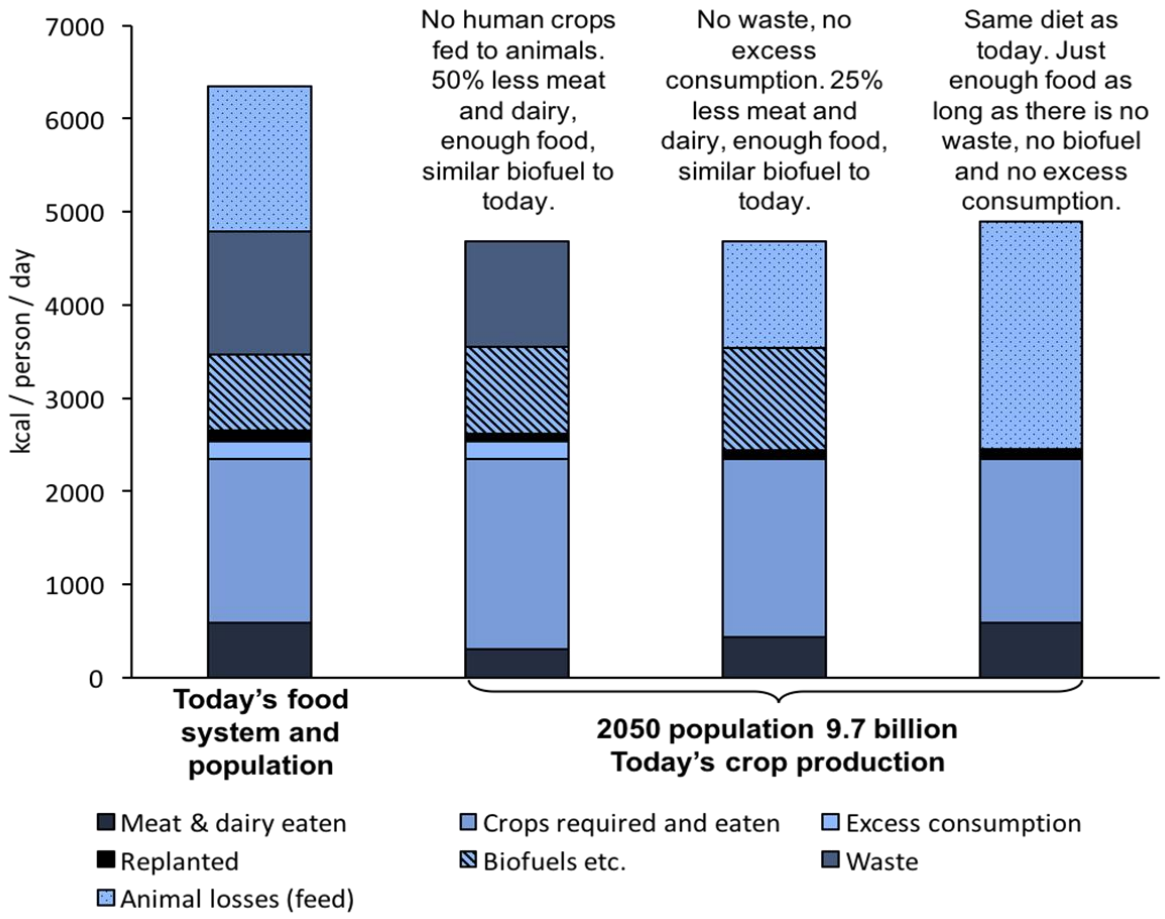

Figure 9. Contrasting scenarios for meeting food demand with global population of around 10 billion. Source: Mike Berners-Lee (2021). There is No Planet B. Adapted from M. Berners-Lee, C. Kennelly, R. Watson, C. N. Hewitt; "Current global food production is sufficient to meet human nutritional needs in 2050 provided there is radical societal adaptation." Elementa: Science of the Anthropocene 1 January 2018; 6 52. doi: https://doi.org/10.1525/elementa.310

The modelling shows that maintaining the current global average diet (right-most bar in Figure 9) could feed the world, but it would require eliminating food waste, excess consumption and

biofuels – considerable challenges in their own right – while also feeding larger quantities of human-digestible crops to animals (see "animal losses (feed)" bar). The other scenarios show that proportionately reducing meat and dairy consumption by, respectively, 25% and 50% allows more of a balanced approach to feeding the world, as it will be very challenging to eliminate waste, biofuels and excess consumption all at once.

The UK View

Bringing it back to the UK context, today the average UK diet is more carbon-intensive than the global average diet, predominantly due to higher meat and dairy consumption. An average UK resident consumes 90% more meat and 75% more total animal products than the global average for 2021. As noted, although the UK represents a small proportion of the global population, its influence is significant and therefore its policies, behaviours and practices are noticed (and often followed) on a global scale. If the UK diet were applied across the world, we would not be able to feed the current global population without further land clearance for agricultural purposes (most environmentally destructive through deforestation) and the subsequent losses in biodiversity and soil carbon. Therefore, to meet its fair share of global efforts to ensure food security and reverse biodiversity losses, UK diets most certainly need to adjust towards current global average diets, and likely further toward the other two options shown in Figure 9 (2nd and 3rd columns; either 50% or 25% less meat and dairy than the current global average).

It is worth noting that the answer to this question is necessarily at a systemic level and thus does not consider key nuances, particularly around nutrition, land use and farming practices, as well as farmers' livelihoods (Question 2). Considering nutrition as well as the population requiring calories and protein as high priorities, it is also important for people to eat a wholesome diet providing good levels of vitamins, minerals and micronutrients. This is a reason for not entirely excluding the consumption of animal products, which when farmed in a more natural way can make an important contribution to nutritional requirements. However, it is possible to get all nutrients from a plant-based diet except for vitamin B12, which is easily obtainable as a food supplement. Furthermore, high levels of meat consumption, especially high saturated fat red meat, is associated with health problems such as coronary heart disease.

Regarding land use, the UK is a mosaic of different landscapes, and therefore location-specific strategies should be devised. For example, where land is dedicated to specific farming practices, it may not be possible to cultivate parts that are too steep, too wet or with poor soil, so such areas could be used for grazing. However, these same pieces of land, which are often the least agriculturally productive areas of the UK's countryside, could be set aside for nature recovery with some conservation grazing rather than grazing livestock for meat or dairy production (see Question 5 for a more in-depth discussion on this).

Finally, the way that land is farmed has a bearing on the nutritional composition and the environmental impact of UK (and global) diets. For instance, regenerative farming practices such as adaptive multi-paddock grazing of livestock on species-rich grasslands can improve soil health, which can in turn lead to higher nutrient quality of meat, and increase soil carbon sequestration fluxes. On the latter, however, it should be noted that according to the current scientific literature, soil carbon sequestration tends to equilibrate after a couple of decades following the adoption of regenerative practices, and therefore any farms that have initially

become net carbon sinks through these practices are unlikely to be able to fully offset carbon emissions (particularly methane) from ruminant livestock in the long run.

Evidence

- The wider debate, data and comments on the climate and land use footprints of UK diets draw on a number of sources, including Poore & Nemecek (2018), Berners-Lee et al. (2018), Ellis et al. (2010), the UN FAO Food and agriculture data, and the Sixth Carbon Budget's Sector Summary for Agriculture and land use, land use change and forestry.
- Calls for more sustainable and healthier diets that would include a cut in meat consumption can be found, e.g. in Lang & Barling (2012), as well as publications by the EAT-Lancet Commission, the FAO and the World Health Organization, the IPCC (2019), and the UK's National Food Strategy report.
- The NHS (2021) report on dietary qualities of meat outlines nutrutional benefits of diets with moderate meat consumption and describes negative health effect of excessive meat consumption.
- Statistics on global land use for livestock compared to nutrient supply are from Ritchie (2019).
- For global population projections, see Earth4All (2022) and the UN DESA (2022).
- Scholars like Fraser et al. (2014), Godfray et al. (2010), and Clonan et al. (2016) have relied on the arguments that global food demand and meat consumption are rising to justify trying to find a way to continue current meat production while mitigating the environmental impact as much as possible. To some extent, these claims are supported by evidence; Whitton et al. (2021), for example, show that global meat consumption is rising in relation to increases in GDP in emerging-economy countries. However, using such findings to advocate for maintaining or increasing current levels of meat production and consumption globally, in line with current consumption levels in the UK, both overlooks the need and ignores the opportunity for dietary shifts to balance food security with environmental sustainability. For a more detailed insight into changes in dietary patterns, please refer to Question 15.
- Regarding equilibration of soil carbon sequestration fluxes with time, a good illustration is provided in the FAO (2022) "Global Soil Organic Carbon Sequestration Potential Map" report. Assessments of the effects of changes in land use and management on soil carbon based on biogeochemical models (e.g. Yumashev et al., 2022) also show this equilibration effect.

15. What conditions would nudge people to shift their eating habits towards more sustainable options?

Context

The question of whether people's dietary patterns will shift away from current levels of meat and dairy consumption arises from doubts about the feasibility of dietary changes as a climate mitigation strategy. Some may resist calls for dietary shifts due to personal food preferences or cultural reasons. However, it is important to ask this question because it addresses the need to rethink the sustainability of current dietary habits, reduce the environmental footprint of food production, and improve public health outcomes.

Arguments seeking to avoid discussions about reducing animal agriculture by asserting that “diets won't change” are quite common; some cite studies linking higher income to increased meat consumption, and global trends showing rising meat consumption, as shown in Figure 10. Additionally, some argue that nudges towards dietary shifts could infringe on personal freedom. However, the substance of this debate is more nuanced. Past shifts in dietary patterns suggest that changes in the global food system and diets can occur, particularly with increasing awareness of moral and existential arguments related to climate change and biodiversity loss.

Answer

Diets have varied and changed throughout human history for different reasons, sometimes over short periods of time. Historically, most people would have improved their health through greater access to meat. This is no longer the case, however, partly because of the dramatically increased availability of plant-based nutrition, and partly because of rising health risks and nutritional degradation of farmed meat, coupled with overconsumption.

The scientific evidence is clear that current levels of meat and animal product consumption are not sustainable, due to their negative impacts on climate change mitigation (Question 4) and adaptation (Question 5), food security (Question 11), and land use (with consequences for biodiversity; Questions 14 and 6). In response to this, many people around the world are already decreasing their meat and dairy intake or switching to vegetarian and vegan diets that provide the nutrients and calories they need, especially in places where plant-based alternatives are readily available. With increased public awareness of the negative impacts of intensive and large-scale livestock production, more plant-based alternatives becoming available, and more calls for a reduction in meat consumption, there is no reason to believe people won’t be willing to make dietary changes.

However, to support this cultural shift, there will also need to be structural changes in the UK’s food production system, especially around fruit and vegetable growing. Over the last 30 years, the growing area dedicated to horticulture has reduced by 37%, from 225,679 ha in 1992 to 141,095 ha in 2022. In addition, the UK’s food market is saturated with so-called “ultra-processed food” (UPF), including plant-based alternative foods that contain emulsifiers, additives and preservatives linked to a number of serious chronic diet-related health problems. Therefore, a systemic improvement in awareness of good food nutrition, cooking skills and direct connection

to local growers is going to be essential in the transition to better diets in the UK. Numerous initiatives are striving towards sustainable food systems, including the Transition Movement and Sustainable Food Places, and a lot more work will be needed over the coming years to deliver the necessary changes.

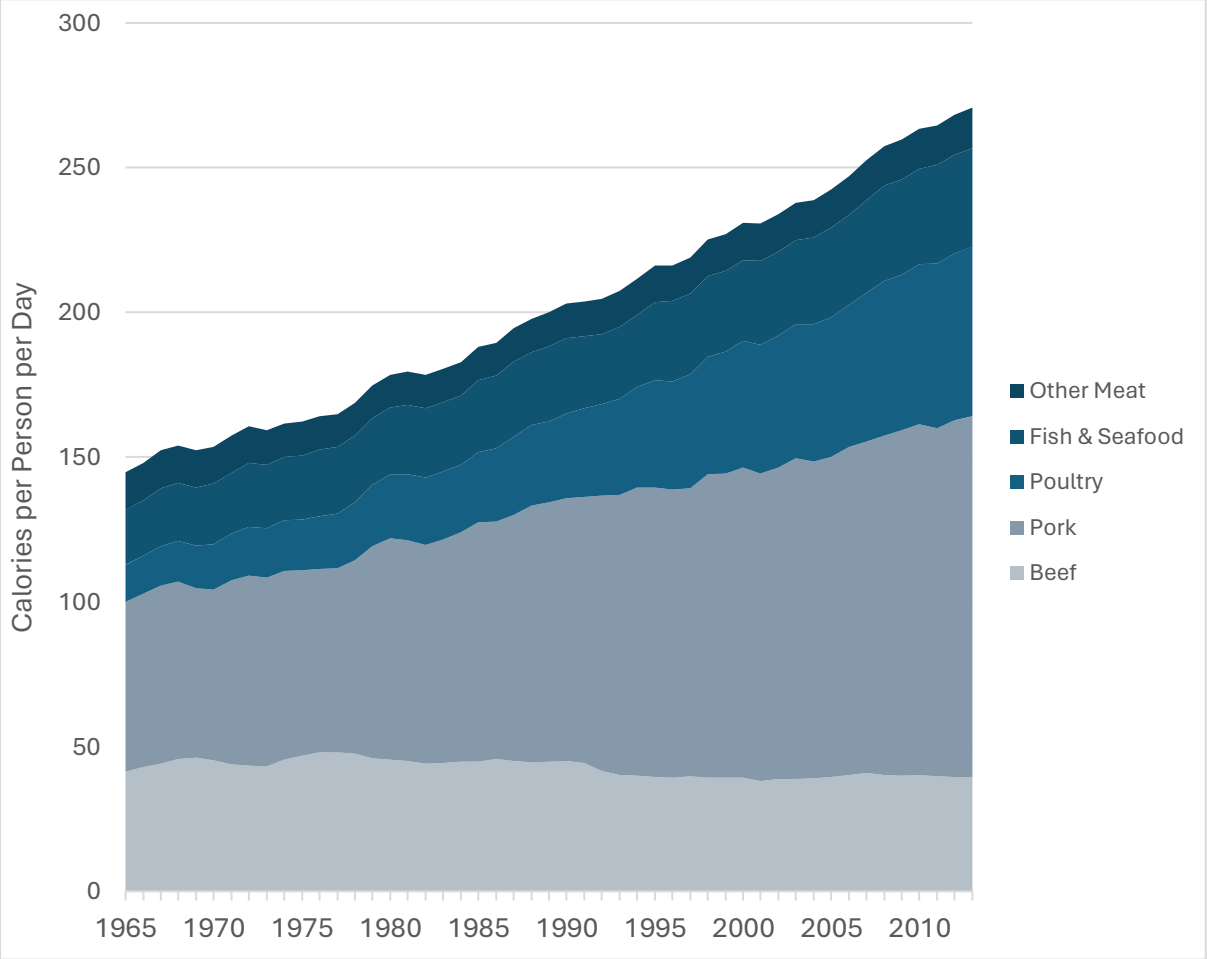

Figure 10. Global meat consumption trends from 1961 to 2013, illustrating the global average energy intake per person per day derived from different types of meat and seafood. Source: FAO Food Balances 2013. https://www.fao.org/faostat/en/#data/FB. Note: the "Other Meat" category is dominated by sheep and goat meat, which account for around 80% of the total for this category.

As a final comment, a key question arises regarding who should be leading this essential transition. Ideally, it would be government-led and come from a position of integrity and values-based policy. However, currently the trajectory seems to be led by the food industry, which holds a lot of power (and data) that influences consumer choice through sophisticated marketing. Ultimately, the ideal outcome would be a strategy owned by the people (through elected government) and designed for the people, leading to diets which are better both for human health and for the environment.

Evidence

- The perspective on dietary shifts and personal freedom, exemplified in the context section by a Telegraph article authored by Noah Eastwood & James Fitzgerald (2023), appears to employ language aimed at provoking division and outrage, rather than

fostering constructive dialogue on animal agriculture and land use. This portrayal overlooks the fact that advocating for dietary shifts to mitigate environmental impacts does not inherently infringe on personal freedom, but rather seeks to promote informed choices for the collective good.

- Stewart et al. (2021) found that between 2008 and 2019, meat consumption in the UK declined according to the National Diet and Nutrition Survey.
- There are indications that some high-GDP countries with historically very high per capita meat consumption rates may have reached "peak meat". There also are suggestions that the relationship between higher GDP and consequently higher meat consumption can only be observed in emerging economies, not in high-income countries. See e.g. Whitton et al. (2021) for further details.
- While not yet mainstream, there is evidence that more people are voluntarily starting to reduce their meat consumption for environmental reasons. See e.g. Sanchez-Sabate & Sabaté (2019).
- The average diet in the UK has changed enormously during the last century, including during WWII at a time of national emergency, post-war increases in meat consumption (Bennett et al., 2018), and the recent rise in veganism due to the planetary emergency (Smith & Prescott-Smith, 2022).
- McAllister et al. (2011) base their paper on the premise that people will continue, if not increase, meat consumption on a global scale. For further data on this, see Ritchie, Rosado & Roser (2017) as well as the FAO's Food Balance Sheets. However, the latter resource also shows that more and more beef, sheep and goat meat has been replaced by poultry when looking at per capita consumption over the past 50 years.
- The DEFRA (2022) Horticulture statistics summarise, among other things, how land area dedicated to horticulture has shrunk over the last 30 years.
- Dr Chris Van Tulleken (author of the book Ultra-Processed People) and Henry Dimbleby (leader of the National Food Strategy and author of the book Ravenous (Dimbleby & Lewis, 2023)) are two prominent individuals highlighting the problems of ultra-processed foods (UPF) and their impact on UK health.

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