Research Paper

Environment and Society Programme

May 2022

Sustainable agriculture and food systems

Comparing contrasting and contested versions

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Summary

- There is significant and growing recognition of the need to transform food systems to reduce their environmental impact. This has increased attention on the need for agriculture to become more ‘sustainable’.
- However, for many reasons, there is no widely agreed conceptualization of how different approaches to agriculture contribute to the sustainability of food systems.
- This paper sets out to compare and contrast two commonly articulated versions of how agriculture and food systems are related, and how food systems may become more sustainable. Version 1 focuses on sparing land for nature, and on increasing the productivity of agricultural land while minimizing environmental impacts; Version 2 focuses on scaling up nature-friendly farming while emphasizing demand-side changes in order to reduce the overall pressure on land.
- For one version to be preferred over another, a range of assumptions are explicitly or implicitly made: these assumptions are presented alongside the related critiques. In each version, a key assumption concerns the role of the market and the degree to which market failure could (or should) be addressed by structural change. This assumption underpins whether large-scale changes in demand (particularly towards healthier diets) are achievable or even desirable.
- If it is assumed that demand will necessarily grow (because the global population and its wealth are projected to increase), it follows that growth in productivity is needed, and sparing land for nature may contribute towards sustainability goals. In contrast, if it is assumed that structural change can occur within markets, and healthier diets can be adopted, demand growth is arguably not a certainty – in which case nature-friendly farming (‘agroecological practices’) can be scaled, because, in comparison with intensive systems, relatively lower yields at farm level pose less of a constraint.
- The arguments in support of both Version 1 and Version 2 of sustainable agriculture and food systems tend to be primarily based on assumptions that may be pragmatic (‘that is the way the world is’), or that may relate to power relationships and politics, particularly with respect to the primacy given to the role of the market. Ultimately, such assumptions have an ideological basis rather than a scientific one. Both versions of sustainable agriculture are informed by a set of assumptions that can be challenged, and these assumptions should be assessed transparently in order to achieve the goal of truly sustainable farming and food systems.

- Transforming agriculture is acknowledged to be important in meeting a range of environmental and social challenges, yet there is a lack of consensus vision for what a transformed and sustainable agriculture should be. Promotion of one version of agriculture over the other has many important implications, including:
  - How sustainability is incentivized across different scales and geographies and, in turn, how major societal challenges, such as climate change, biodiversity loss and human health, are tackled.
  - Whether coherence at the international level can occur across climate, nature, food and health agendas to tackle the goals jointly with similar approaches.
  - Whether it is possible to channel investments in innovation to deliver better systemic outcomes.
  - Whether there can be better coordination between civil society and progressive corporations to drive change.
- Given that the promotion of one version of sustainability in agriculture has profound implications, a transparent and critical analysis of what is being assumed to enable that version to be achieved sheds light on the extent to which that vision may, or may not, be achievable.

01 Introduction

Assumptions underlying different models of sustainable agriculture must be tested for robustness – in this way the risks of path dependence can be reduced.

The unsustainability of agriculture and food systems is receiving unprecedented news coverage due to the increasingly well documented range of interlinked adverse impacts: the role in driving climate change, by accounting for about 37 per cent of anthropogenic greenhouse gas emissions;[1] the contribution to deforestation and declining biodiversity;[2] the input to air and water pollution;[3] the degradation of soils;[4] and the role in driving the emergence and/or spread of disease (e.g. COVID-19) or antimicrobial resistance.[5] Furthermore, increasing concern is being paid to the resilience of food systems to climate change, and the role of climate change itself in undermining food security, supply-chain disruption and food price spikes.[6] Given these headline topics, the question of how agriculture can be made 'sustainable' is increasingly at the forefront of debates taking place at international meetings (e.g. the first UN Food Systems Summit in September 2021, the UN Framework Convention on Climate Change's COP26 in November 2021 and the forthcoming COP15 of the UN Convention on Biological Diversity in late 2022), as well as discussions in the media and on social media. Getting agriculture 'right' within the context of wider global food systems can contribute to improvements both in environmental outcomes for climate, soils, water and biodiversity, and in nutritional outcomes for public health.

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1 Xu, X. et al. (2021), 'Global greenhouse gas emissions from animal-based foods are twice those of plant-based foods', *Nature Food*, 2, pp. 724–32, https://www.nature.com/articles/s43016-021-00358-x.
2 Benton, T. G. et al. (2021), *Food system impacts on biodiversity loss: Three levers for food system transformation in support of nature*, Research Paper, London: Royal Institute of International Affairs, https://www.chathamhouse.org/2021/02/food-system-impacts-biodiversity-loss.
3 Kanter, D. R. et al. (2020), 'Gaps and opportunities in nitrogen pollution policies around the world', *Nature Sustainability*, 3, pp. 956–63, https://doi.org/10.1038/s41893-020-0577-7.
4 Lal, R. (2019), 'Managing soils for resolving the conflict between agriculture and nature: The hard talk', *European Journal of Soil Science*, 71(1), pp. 1–9, https://doi.org/10.1111/ejss.12857.
5 Amuasi, J. H., Lucas, T., Horton, R. and Winkler, A. S. (2020), 'Reconnecting for our future: *The Lancet* One Health Commission', *Lancet*, 395(10236), pp. 1469–71, https://doi.org/10.1016/S0140-6736(20)31027-8.
6 Intergovernmental Panel on Climate Change (2019), 'Climate Change and Land: An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems', https://www.ipcc.ch/srccl; UK Government (2022), *Technical Report of the Third UK Climate Change Risk Assessment (CCRA3)*, UK Climate Risk, https://www.ukclimaterisk.org/independent-assessment-ccra3/technical-report.

While there is no agreed definition of sustainable agriculture, there is a vast body of literature on the many environmental impacts which result from farming practices. It is evident from the literature that agreeing on what makes agriculture sustainable is difficult, for the following reasons:

- Agriculture can have multiple impacts on the environment (through pollution, affecting soil, air or water quality; emissions of greenhouse gases; soil degradation; or the reduction or degradation of habitats, resulting in biodiversity loss). Reducing one metric (e.g. greenhouse gas emissions) may bring about a trade-off in terms of other metrics (e.g. biodiversity loss).
- Context dependence must be taken into account. The same practice, undertaken in different places, can have different outcomes on the same aspect of sustainability, due to local variations in environment or climate.
- Many environmental impacts vary with the scale of the intervention (or its frequency). For example, the intensive management of a single field in a large area of agroecological farmland may not affect local biodiversity to a measurable extent; but if the same agricultural practice was scaled up to landscape level, it would. Hence, it is difficult to characterize a practice as sustainable – or unsustainable – without reference to the scale of its implementation.
- In a market-driven system, the demand for agricultural outputs gives rise to linkages between production areas, even if they are in different countries. This means that if yield is sacrificed to reduce environmental impacts in one place, then in order to meet demand the market will incentivize production in other places, potentially with lower standards for environmental governance. Increases in production could be achieved through agricultural intensification, or by clearing land in order to convert it to farmland: and, in aggregate, this process reduces the sustainability of the overall food system.

Therefore, there may not be a simple approach to defining sustainability in agriculture without simultaneously also defining sustainability in food systems as a whole[7] – and, more broadly, examining how land and other key resources are used by different sectors globally.

The following thought experiment serves as a useful illustration of the complexities involved. Let us imagine that research highlights a new farming system which reduces greenhouse gases, conserves biodiversity, stores carbon, maximizes animal welfare and preserves the cultural, recreational and amenity value of the landscape. While yields are only 70 per cent of those achieved through standard intensive farming practices, the public goods are improved to such an extent

7 Where the food system comprises the actions taken to produce, transport, manufacture, sell and consume food. Outcomes from the food system include food security, human health through diet and the environmental impacts arising from the food system.

that they more than compensate, in terms of economic value, for the relatively lower yields at the level of individual farms. Whether this farming system is more sustainable is illustrated by considering the following two hypothetical cases:

— (1) Demand for food stays the same, i.e. consumers continue to eat the same types and amounts of food: in which case, if the 'sustainable agriculture' system were to be adopted globally, it would imply that the area of agricultural land would have to be expanded by at least 42 per cent (i.e. 1 divided by 0.7) to make up for the reduction in yield. Land clearance for this purpose would release greenhouse gas emissions, cause biodiversity losses, and degrade water quality and availability around the world. This would suggest that, despite being more sustainable locally, the proposed form of agriculture might lead to a less sustainable system as a whole.

— Alternatively, in hypothetical condition (2), demand for food changes: people are incentivized not to waste food, to adopt a healthy diet rich in plant-based foods, and to avoid excess consumption. With a fall in demand of 30 per cent, all farms could adopt the new, hypothetical, farming system, while delivering the raft of environmental benefits and without needing to expand the land 'footprint' of agriculture. So, the same farming system could be seen to be unsustainable in case (1) but sustainable in case (2).

As this scenario illustrates, the criteria for what makes agriculture sustainable or not are often confusing and contested. This confusion often arises due to a lack of clarity about whether sustainability is being discussed in the literature as a property of the agricultural system, or the farm, or the context, or the aggregate or relative impact (in terms of the food system's environmental footprint, or the footprint per kg of agricultural product). The aim of this paper is to unpack some of the framing issues and examine the underlying assumptions being made in different discussions, thus bringing some clarity as to how particular arguments are being made – from different viewpoints – which underpin perspectives on how agriculture may become more sustainable.

The goal of the paper is to provide transparency as to why there are different – logically consistent and plausible, but nonetheless deeply contested – models for sustainable agriculture and food systems. This systemic appraisal is built on an examination of the robustness of the underlying assumptions, and is relevant to a wide range of actors within global food systems, including political decision-makers, investors and corporate stakeholders, as well as civil society actors. These assumptions may not be apparent: instead, they may be implicit, or unexamined, but often they are based rather less on strong evidence and more on what proponents may think is desirable, including from an ideological[8] perspective. On one level, this paper is about definitions, but it is, to a greater extent, about the enabling assumptions that are made to underpin and legitimize different directions of travel in order to achieve the 'sustainability transition'.

8 Where an ideology is a 'system of beliefs, ways of thought, and categories that provide the foundation of programmes of political and social action' (Blackburn, S. (2016), *The Oxford Dictionary of Philosophy*, https://doi.org/10.1093/acref/9780198735304.001.0001).

In short, the assumptions that are made to support a particular version of how agriculture affects the sustainability of food systems serve to channel policymakers and investment in certain directions. In turn, choosing a specific version of sustainability of agriculture has huge implications for both the amount and type of foods that are produced and for the impact of agriculture on climate change, pollution, biodiversity loss and human health. Given the urgency of tackling each of these issues, examining the robustness of the underlying assumptions that support a given direction of travel will reduce the risks of a 'path dependence' that aims to increase sustainability but does not achieve the necessary sustainability goals.

Unpacking the narratives that support different 'versions' of sustainable agriculture

To analyse the principal narratives on sustainable agriculture, this paper contrasts alternative 'versions', conceptually similar to 'mindsets' or paradigms, originally described by Donella Meadows in 1999 thus: 'The mindset or paradigm out of which the system – its goals, power structure, rules, its culture – arises'.[9] The 'versions' of sustainable agriculture within sustainable food systems presented below (Table 1) bear some similarities to the contrasting hypothetical cases described above. Version 1 focuses on agricultural intensification to raise yields per unit of area through production gains, while minimizing environmental impacts (primarily focusing on the efficiency of agricultural production), and 'sparing' land from agriculture. Version 2 focuses on agroecological (nature-friendly) approaches that produce lower yields but with lower environmental impacts, and thus contributes to 'sharing' land with nature/wildlife.

The key assumptions made in the arguments that link agricultural practice at the farm level and the impacts on food systems more generally are laid out in Table 1 (and discussed at length below). Both versions are logical and internally consistent subject to their assumptions. The core difference between the two versions is in the assumption about the future of demand (and thus the amount of land and mode of farming that are necessary to meet it). How demand may (or may not) grow depends on a range of factors, including the way the market works (or how it might work). These assumptions often have an ideological basis that is sometimes, but not always, explicitly acknowledged.

As an example of the debate, a common perspective is that intensive farming wearing the guise of 'sustainable' intensification is a more valid, more pragmatic, approach to sustainable food production than nature-friendly, agroecological farming. This is in spite of the fact that the vast majority of the academic literature comparing conventionally intensive and agroecological farms shows that the latter are associated with greater biodiversity, more stored carbon, more productive soils and, perhaps, less pollution. In other words, the empirical data support the claim that intensive farming is more environmentally impactful (less 'sustainable') at the

9 Meadows, D. H. (1999), 'Leverage Points: Places to intervene in a system', Report, Hartland, VT: The Sustainability Institute, text available at https://donellameadows.org/archives/leverage-points-places-to-intervene-in-a-system.

field, farm and landscape levels, but the assumptions made about scale effects lead to the reverse conclusion. In essence, the debate is therefore not so much about the evidential basis of sustainability, but the assumptions made in its interpretation.

Table 1. Two versions of sustainable agriculture and their key assumptions: a summary

Version 1	Version 2
'Sustainable' intensification and land sparing to meet an inevitably increasing global demand for food.	Agroecological approaches with land sharing and sparing, enabled by demand reduction through the adoption of healthy, sustainable, low-waste food consumption.
Key assumptions	**Key assumptions**
Demand is exogenous, and will increase as population size and wealth increase.	Demand can be changed, and should be shaped by social needs.
Growing market demand requires productivity growth to raise supply.	The current unsustainability of farming is a form of market failure that can be corrected to reduce demand.
Dietary change is difficult, and is not the preserve of policy.	A healthy diet is also a (more) sustainable one.
The potential for technologically led sustainable intensification is substantial.	Agroecological approaches can supply sufficient nutrients to 'feed the world', if consumption patterns change.
Land sparing is enabled by sustainable intensification.	Agroecological approaches are more sustainable than sustainable intensification.

Source: Chatham House research.

A note on terminology

In this paper, the terminology '"sustainable" intensification' is deliberately used to differentiate it from the academic concept of 'sustainable intensification' in Version 1. As is discussed in more detail below, 'sustainable intensification' is a concept that relates intensification (producing more) with a reduction in environmental impacts to increase sustainability. Conceptually, it covers a spectrum from efficiency gains in production ('more for less') to food system redesign. Version 1 uses the term as co-opted by many stakeholders, and practised by many farmers, in the sense of intensifying while improving efficiency. This usage is more akin to plain intensification, and has the potential to confuse the reduction of relative impacts through efficiency gains (e.g. 10 per cent less nitrogen use per tonne of grain) with absolute impacts (increasing yields by >10 per cent will lead to absolutely more nitrogen usage and therefore larger impacts, all other things being equal). Because this is arguably not more sustainable, this paper characterizes the commonly operationalized, 'more for less' efficiency-gaining form of sustainable intensification as 'sustainable' intensification, while recognizing that other forms of sustainable intensification conceptually and theoretically may lead to significant and real environmental gains, particularly through system redesign and the adoption of agroecological approaches.[10]

The term 'regenerative farming' has recently grown in prominence. It refers to farming that uses soil conservation to regenerate and deliver ecosystem services, and to enhance the environmental, social and economic aspects of food production.

As an academic field, 'agroecology' (a term often used to describe the relationship between ecology and agriculture) is 'the integrative study of the ecology of the entire food system, encompassing ecological, economic and social dimensions, or more simply the ecology of food systems'.[11] Agroecology is also used to describe how farming can work with nature and ecology to aid production, through supporting natural processes that enhance soil fertility, pollination or pest control, and it can include suites of practices like organic farming, integrated farm management and agroforestry. The term 'regenerative farming' has also recently grown in prominence, referring to farming that uses soil conservation to regenerate and deliver ecosystem services, and to enhance the environmental, social and economic aspects of food production.[12] In this paper, the term 'agroecological approaches' is used to refer to natural processes that can support farming; such approaches can contribute to sustainability gains on intensive farms, without them necessarily converting wholesale – a process sometimes called 'ecological intensification'.[13]

The two versions summarized in Table 1 are necessarily generalized, and it is perfectly possible to favour one version over another on pragmatic grounds (particularly Version 1, on the basis of 'that is the way the world works'), rather than more explicitly on the basis of ideology or analysis. Nonetheless, the aim of this paper is to clarify the conceptual basis in terms of how the mode of agriculture is assumed to deliver sustainability at the level of the food system. The paper focuses throughout on sustainability in the broad sense of environmental sustainability, while recognizing that a range of wider social metrics (e.g. income and livelihoods, social cohesion or development needs) could be applied. In the following sections, each of the versions will first be described and then examined in detail. Each underpinning assumption will be discussed in turn, with the arguments made in support of each assumption being presented alongside the arguments against (the critiques).

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10 Baulcombe, D. et al. (2009), *Reaping the benefits: science and the sustainable intensification of global agriculture*, London: The Royal Society, https://royalsociety.org/~/media/royal_society_content/policy/publications/2009/4294967719.pdf.
11 Francis, C. et al. (2003), 'Agroecology: The ecology of food systems', *Journal of Sustainable Agriculture*, 22(3), pp. 99–118, https://www.tandfonline.com/doi/abs/10.1300/J064v22n03_10.
12 Schreefel, L. et al. (2020), 'Regenerative agriculture–the soil is the base', *Global Food Security*, 26 (100404), https://doi.org/10.1016/j.gfs.2020.100404.
13 Bommarco, R., Kleijn, D. and Potts, S. G. (2013), 'Ecological intensification: harnessing ecosystem services for food security', *Trends in Ecology & Evolution*, 28(4), pp. 230–38, https://www.sciencedirect.com/science/article/abs/pii/S016953471200273X.

02 Version 1: 'Sustainable' intensification and land sparing

Food production must increase to satisfy growing demand. Efficiency gains – primarily through the use of technology – will allow biodiversity-rich land to be protected from agricultural expansion, and ecosystems to be restored on unused land.

The case made for this version of sustainability

Global demand for food is typically assumed to be mainly determined by the size of consumer populations and their purchasing power, and as such demand is set outside of food systems (it is an exogenous variable). As both global population and global wealth are increasing, demand is therefore assumed to be set on an unchangeable trajectory of increase. Farm outputs must rise to match demand growth, and yield growth is the key variable of importance, often phrased in terms of increasing productivity. Trade is assumed to be an important enabler for global food security, leading to the supposition that production should be maximized via comparative advantage in order to 'feed the world'.

Under the assumption that demand will grow, to enable land use to be sustainable overall, biodiversity-rich natural land should be protected from agricultural expansion, and portions of unused land should be restored to native ecosystems. The rationale for this is that native ecosystems are associated with the highest levels of biodiversity and natural capital. Land should therefore be 'spared for nature'.[14]

If it is assumed that demand will inevitably grow, and that agricultural expansion is not possible because of sparing land for nature, then it follows that more food must be grown per unit of area. This is a definition of intensifying agriculture, but any such intensification should be done while reducing the environmental impact:[15] in other words, intensification should be sustainable. Given the necessity of meeting demand, yield is often seen as the primary output, and gains in sustainability are primarily driven through gains in efficiency, limiting inputs to yield-maximizing levels to prevent leakage of fertilizers or pesticides. Some assert the need to consider reducing yields in some places in order to gain sustainability where environmental costs are large,[16] on the typical assumption that yield increases arising from sustainable intensification in other places will compensate to enable global production to continue increasing.

The predominant focus is on gaining efficiency through raising outputs while reducing inputs (land, labour, synthetic inputs), primarily through the use of technology: genetics that increase yields (and resilience to climate impacts and/or pests) and precision agriculture (in which the 4Rs principle applies: putting the right inputs in the right places, at the right times and in the right amounts).

Version 1 requires technological developments in genetics and precision management of crops or livestock, utilizing data (e.g. from satellites, drones or on-the-ground sensors) and data analytics connected to smarter machinery. Beyond increased efficiency – which typically aligns with notions of increasing profitability for farmers, and therefore is often part of the normal 'direction of travel' for intensive farmers – proponents argue for (a) increasingly substituting processes in order to gain environmental goals (e.g. natural pest control through integrated pest management, rather than pesticides as a first resort), and (b) redesigning farming systems towards those that regenerate, rather than erode, natural capital.[17]

Given that demand is set to grow and might exceed the ability to supply, and given the key assumption that land sparing can be enabled by intensification, the associated notion of any change in demand is to treat products with a lower environmental footprint as being by definition more sustainable, as they are more environmentally efficient (in relation to their impact per unit of production: for example, kg of carbon dioxide equivalent – $kgCO_2e$ – per kg of product). Thus, within the discourse on sustainable agriculture and food, life cycle assessment is the prime technique of analysis, leading to a substitution hierarchy (e.g. from beef to chicken to beans). Given the primacy accorded to meeting projected

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14 Balmford, A. (2021), 'Concentrating vs. spreading our footprint: how to meet humanity's needs at least cost to nature', *Journal of Zoology*, 315(2), https://doi.org/10.1111/jzo.12920.
15 Garnett, T. et al. (2013), 'Sustainable Intensification in Agriculture: Premises and Policies', *Science*, 341(6141), pp. 33–34, https://doi.org/10.1126/science.1234485.
16 Ibid.; Buckwell, A. et al. (2014), *Sustainable Intensification of European Agriculture*, Brussels: RISE Foundation, https://risefoundation.eu/wp-content/uploads/2020/07/2014_-SI_RISE_FULL_EN.pdf.
17 Pretty, J. et al. (2018), 'Global assessment of agricultural system redesign for sustainable intensification', *Nature Sustainability*, 1, pp. 441–46, https://doi.org/10.1038/s41893-018-0114-0.

demand in the market, there is a strong discourse around innovating 'alternative proteins' as a market-led way to replace one form of production with another, less resource-intensive, one. Hence, there is an important drive to innovate in, among other things, non-soy plant proteins (e.g. peas), industrial bio-fermentation (fungi, bacteria), algal systems (seaweed and single cells in closed systems), and insects (as generic protein, for human and livestock feed), as well as cellular and other forms of 'meat'.[18]

Examination of the key assumptions underpinning the framing of Version 1

Given the narrative above, this section will examine the key assumptions underlying Version 1 together with their critiques. Table 2 provides a summary, and is followed by a more detailed discussion of each assumption in turn: these are each subdivided into two sections, headed 'Framing' and 'Critique'.

Table 2. Sustainable agriculture, Version 1: 'Sustainable' intensification and land sparing to meet inevitably increasing global food demand

Key assumptions	Critique
Demand is exogenous and **will increase** as population size and wealth increase.	Given health externalities, as well as environmental ones, past patterns are not a strong guide to future demand. **Diets can change rapidly** (e.g. as a consequence of nutrition transitions or the COVID-19 pandemic).
Growing market demand requires productivity growth to raise supply.	Market failure **can be corrected** by structural change to deliver better public goods, reducing aggregate demand.
Dietary change is difficult and is **not** the preserve of policy.	Given the right levers, **diets can change rapidly**. Diets (like tobacco and alcohol use) should be shaped by social needs.
The potential for technologically led sustainable intensification is **substantial**.	Technically this may be true, but operationally it may create trade-offs (e.g. greater yields may require absolute increases in inputs, even if they are relatively more efficient). More focus should be given to 'what is grown' than to 'how more can be grown'.
Land sparing is **enabled** by sustainable intensification.	Intensification is more likely to enable **land clearance** than land sparing, through spillover effects.

Source: Chatham House research.

18 Wellesley, L. and Froggatt, A. (2019), *Meat Analogues: Considerations for the EU*, Research Paper, London: Royal Institute of International Affairs, https://www.chathamhouse.org/2019/02/meat-analogues.

Assumption 1: Demand is exogenous to supply and will necessarily increase

Framing: Global food demand is typically projected on the basis of past demand growth (or today's price elasticities) decomposed into a function of income and population size, with the assumption that existing relationships can be projected forwards.[19] Given that, globally, both economic growth and population growth are projected to increase, this gives rise to the underlying assumption that demand for food will grow, as the poor get richer and demand more – in particular, more meat and dairy. Thus, demand growth is set externally to food systems, being 'locked in' by population and economic growth. Of the two, some analyses identify the contribution of per person wealth-related economic growth as having a bigger overall impact on demand than population growth.[20]

Critique: First, increasing recognition of the effects of excessive consumption on human health and well-being, and planetary health,[21] may alter behavioural, regulatory or market incentives, and change purchasing patterns (in particular, decreasing consumption of ultra-processed food and livestock products, and increasing fruit and vegetable intake). Similarly, changes in food availability and price (e.g. driven by environmental, geopolitical or geo-economic change) may shift consumer demand and reshape consumption patterns (see Version 2, Assumption 1). Hence, given that some of the factors shaping demand are not static, it may not be robust to assume that past consumption is a necessary determinant of future consumption.

Second, demand is not exogenous to the system or supply: it is influenced by market dynamics. In the 19th century, the economist W. S. Jevons pointed out that efficiency gains can reduce prices which, if passed onto the consumer, can lead to demand growth through stimulating consumption.[22] This leads to a 'paradox of productivity' – the greater the focus on innovation in agriculture, the more stimulation is given to demand growth.[23] In addition, capitalism is underpinned by economic incentives to increase consumption, and is thus inherently market-expanding.[24] Therefore, assuming demand will only grow according to wealth and population size probably underestimates the scope for demand growth. Hence, intensifying agricultural production to meet demand, in order to spare land, has the potential to under-deliver in that respect. Any increase in incentives for land conversion may undermine future regulatory or voluntary actions to protect spared land.

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19 Tilman, D., Balzer, C., Hill, J. and Befort, B. L. (2011), 'Global food demand and the sustainable intensification of agriculture', *Proceedings of the National Academy of Sciences*, 108(50), pp. 20260–64, https://doi.org/10.1073/pnas.1116437108; Tilman, D. and Clark, M. (2014), 'Global diets link environmental sustainability and human health', *Nature*, 515(7528), pp. 518–22, https://doi.org/10.1038/nature13959; Valin, H. et al. (2014), 'The future of food demand: understanding differences in global economic models', *Agricultural Economics*, 45(1), pp. 51–67, https://doi.org/10.1111/agec.12089; Food and Agriculture Organization of the UN (2017), *The future of food and agriculture: trends and challenges*, Rome: FAO, https://www.fao.org/3/i6583e/i6583e.pdf.
20 Fukase, E. and Martin, W. (2020), 'Economic growth, convergence, and world food demand and supply', *World Development*, 132(104954), https://doi.org/10.1016/j.worlddev.2020.104954.
21 Swinburn, B. A. et al. (2019), 'The global syndemic of obesity, undernutrition, and climate change: *The Lancet* Commission report', *Lancet*, 393(10173), pp. 791–846, https://doi.org/10.1016/S0140-6736(18)32822-8.
22 Alcott, B. (2005), 'Jevons' paradox', *Ecological Economics,* 54(1), pp. 9–21, https://doi.org/10.1016/j.ecolecon.2005.03.020.
23 Benton, T. G. and Bailey, R. (2019), 'The paradox of productivity: agricultural productivity promotes food system inefficiency', *Global Sustainability*, 2(E6), https://doi.org/10.1017/sus.2019.3.
24 Hall, S. and Davis, M. (2021), 'Permission to Say "Capitalism": Principles for Critical Social Science Engagement with GGR Research', *Frontiers in Climate*, 3, https://doi.org/10.3389/fclim.2021.708913.

The assumption that demand is predictable and fixed, and can therefore be met by intensifying production to allow land to be spared from agricultural expansion, is therefore a weak assumption (see also critique to Version 1, Assumption 5, below). Demand is not a 'given' – it is an endogenous variable that can be changed, whether positively or negatively.

Assumption 2: Growing market demand requires productivity growth

Framing: It is central to current economic thinking that markets are the best mechanism for increasing prosperity and that suppliers should be enabled to meet demand in ways that are most efficient and productive, without interventions or regulation (often referred to as 'red tape'[25]) that may constrain supply, and thus price. The free-market view is that if demand exists (or can be created), profit can be made from supplying that demand. Changing the structure of the market to constrain demand or supply reduces potential economic growth, and is therefore to be avoided.

Further, it is often implicitly assumed that farmers would not farm in ways that are not economically sustainable, and therefore environmental regulation is an unnecessary form of red tape which increases the costs of production. Similarly, many free marketeers, as well as many politicians, would suggest that if people want to consume goods that are bad for their dietary health or that increase greenhouse gas emissions or biodiversity losses, they should be entitled to,[26] and the market should not be specifically structured around regulation for reasons related to public goods. Regulation is seen to impinge directly on the economic public goods that arise from reducing prices, increasing choices and allowing different forms of consumption that contribute to economic growth.

Thus, competitive markets drive innovation, leading to increasing efficiency and lower prices. As declared by the US Department of Agriculture's Economic Research Service:

> Productivity growth in agriculture has allowed food to become more abundant and cheaper even as the world's population has increased.[27]

This view is very deeply entrenched. Agriculture is often framed as an economic sector, and farmers as market actors, with the role of contributing to meeting demand (often erroneously characterized as 'feeding the world') by growing more food. This framing leads to a discourse that it is the 'moral duty' of farmers to contribute to maximizing on-farm productivity growth, and that adoption of new

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25 For example: UK Department for Environment, Food & Rural Affairs and The Rt Hon Owen Paterson MP (2013), 'Agriculture red tape to be removed', press release, 17 July 2013, https://www.gov.uk/government/news/agriculture-red-tape-to-be-removed.
26 Eley, J., Parker, G., Hancock, A. and Evans, J. (2021), 'Boris Johnson rejects proposal to tax sugar and salt in food', *Financial Times*, 15 July 2021, https://www.ft.com/content/9687484f-2703-4e55-a37a-827a056ac962; Laville, S. (2021), 'UK meat tax and frequent-flyer levy proposals briefly published then deleted', *Guardian*, 20 October 2021, https://www.theguardian.com/environment/2021/oct/20/meat-tax-and-frequent-flyer-levy-advice-dropped-from-uk-net-zero-strategy.
27 U. S. Department of Agriculture, Economic Research Service (2022), 'International Agricultural Productivity', https://www.ers.usda.gov/data-products/international-agricultural-productivity.

technologies is often the best route.[28] This view is sometimes extended to imply that if on-farm productivity is not maximized via new technologies, farms become inefficient and wasteful, and their farmers should make way for productivity-focused agriculturalists who can maximize a nation's comparative advantage and thus contribute to maximizing its economic growth. Farmers who do not meet such expectations may therefore be subject to forms of peer pressure.[29]

Such a discourse on maximizing productivity mainly through new technologies is articulated across the world. For example, in the case of England, the UK Department for Environment, Food and Rural Affairs (DEFRA) stated in its 2018 white paper *Health and Harmony: the future for food, farming and the environment in a Green Brexit*:

> There is a huge opportunity for UK agriculture to improve its competitiveness – developing the next generation of food and farming technology, adopting the latest agronomic techniques, reducing the impact of pests and diseases, investing in skills and equipment and collaborating with other farmers and processors. We want our future policy to provide an enabling environment for farmers to improve their productivity and add value to their products, so they can become more profitable and competitive.[30]

The assumption that demand growth requires productivity growth entrenches the view that increasing scale and intensity of farms is a necessary, unidirectional component of agriculture: farms should get ever bigger, and ever more technologically developed, in order to maximize productivity, and small, inefficient farms should disappear. According to the summary of a 2016 workshop organized by the Committee on Agriculture and Rural Development and Policy Department B of the European Parliament:

> Conventional agro-political discourse and scientific theory (especially agricultural economics) generally understands structural change as being a uni-directional process that involves the gradual disappearance of small farms and an associated enlargement of large farms. This process is also understood as involving the continual replacement of labour by capital and technology. For decades the main focus of agricultural policies at both the national and supra-national levels has been to support and encourage structural change. At the same time structural change has generally been perceived to be an inevitable process and all the available statistical material from the Western [member states of the EU] seems to unambiguously support such an interpretation.[31]

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28 Country Smallholding (2008), 'Farmers 'have moral duty to help feed the world'', 19 February 2018, https://www.countrysmallholding.com/grow-and-maintain/farmers-have-moral-duty-to-help-feed-the-world-8250134.
29 Sutherland, L.-A. et al. (2012), 'The 'Neighbourhood Effect': A multidisciplinary assessment of the case for farmer co-ordination in agri-environmental programmes', *Land Use Policy*, 29(3), pp. 502–12, https://doi.org/10.1016/j.landusepol.2011.09.003.
30 UK Department for Environment, Food & Rural Affairs (2018), *Health and Harmony: the future for food, farming and the environment in a Green Brexit*, p. 7, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/684003/future-farming-environment-consult-document.pdf.
31 European Parliament Directorate-General for Internal Policies (2016), 'Research for Agri Committee – Structural Change in EU Farming: How Can the CAP Support a 21st Century European Model of Agriculture?', Workshop, p. 16, https://www.europarl.europa.eu/RegData/etudes/STUD/2016/573428/IPOL_STU(2016)573428_EN.pdf.

Given the strength of the assumption that demand needs to be met through productivity growth, it also follows that the **most sustainable system is one which maximizes productivity in places with comparative advantage** and avoids productivity in places with comparative disadvantage. Trade liberalization is therefore a key part of enabling efficient land use on a global basis.

Critique: Demand is influenced by price and by the market itself (e.g. through marketing – see critique of Assumption 1), and productivity growth can, through the 'Jevons paradox', increase demand, by reducing prices and increasing availability, and decrease the efficiency of the whole system by increasing its environmental and human costs. If productivity growth leads to greater per person availability beyond human metabolic limits, it will result in either ill health and/or food waste. Hence, while proponents of the market-led framing of Version 1 argue for productivity growth to 'feed the world' through meeting demand growth, such growth may instead contribute to more waste and excess food consumption for the majority of the global population. The notion that people should be entitled to eat food that has negative attributes (in terms of their health and/or environment) can be countered by research that suggests many people buy such foods not because of inherent preference, but because of affordability and accessibility. Many examples of social research suggest that if lower-impact foods were more affordable, people would prefer to consume them[32] (see critique to Version 1, Assumption 3, below).

Furthermore, demand globally is met and enabled by increasingly significant international trade in commodities. While trade can optimize land use through maximizing comparative advantage, aspects of the comparative advantage can include weak environmental and social governance. Given the notion that demand should be met, privileging market needs over environmental and social protection can lead to a global 'race to the bottom', via the vicious circles of the Jevons paradox:[33] more demand creates more economic value, which increases profits and market share, and as the volume produced increases, prices fall which in turn increases demand.

Assumption 3: Dietary change to reduce demand is 'difficult' and not the preserve of policy

Framing: A core tenet of neoliberal thinking is that markets allow individuals to meet their preferences, which in turn drive the behaviour of markets.[34] Various studies have concluded that 'nudges' to change consumption behaviour may work, but only to a limited extent.[35] This reinforces the view that existing consumption patterns are 'revealed preferences' (showing what consumers really want to consume) and that demand elasticities (how consumption changes with marginal price changes) are often relatively inelastic. Given these assumptions, future demand will depend on the increased consumer purchasing power enabled by economic growth, more

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32 Food, Farming and Countryside Commission (2022), *Hungry for health: What citizens want from food*, London: FFCC, https://ffcc.co.uk/assets/downloads/FFCC-HungryForHealth-What-citizens-want-from-food.pdf.
33 Benton and Bailey (2019), 'The paradox of productivity'.
34 Isenhour, C. (2010), 'On conflicted Swedish consumers, the effort to stop shopping and neoliberal environmental governance', *Journal of Consumer Behaviour*, 9(6), pp. 454–69, https://doi.org/10.1002/cb.336.
35 Nisa, C. F., Bélanger, J. J., Schumpe, B. M. and Faller, D. G. (2019), 'Meta-analysis of randomised controlled trials testing behavioural interventions to promote household action on climate change', *Nature Communications*, 10(4545), https://doi.org/10.1038/s41467-019-12457-2.

so than on changes in total population size[36] or in consumer preferences. This implies a 'locked-in' assessment of demand, so that attempting to change consumption patterns is taken to be of marginal utility, compared with technological innovation on the supply side,[37] in making food systems more sustainable.

From a political perspective, the argument that the state should not be involved in shaping citizens' consumption is often more forcefully expressed. For example, US Senator Michael Crapo has been quoted as saying: 'It is not government's job to mandate responsibility on our [citizens'] behalf. We have the intelligence and good sense to make wise consumption choices for ourselves and our children. It is up to us to do what is best for our health and our children's health.'[38] In 2021, the UK Secretary of State for Environment, Food and Rural Affairs, George Eustice, was reported to have said that it is not the role of government to lecture consumers on changing their diets,[39] and Prime Minister Boris Johnson rejected the National Food Strategy's suggested interventions towards healthier diets: as was reported by the *Daily Mail*, 'Boris Johnson slaps down his eating tsar's 'nanny state' call'.[40] This view is often entrenched in the libertarian right, where it is anathema for government to intervene to limit personal choices,[41] even for the public good.

If the industrialization and intensification of agriculture undermine healthy consumption patterns, this weakens the proposition that further intensification could be the main part of the solution of how to feed people healthily.

Critique: The first critique of the 'diets are difficult to change' argument is that diets are continually changing – as evidenced by the global nutrition transition, there have been 'major shifts in diet […] toward[s] increased refined carbohydrates, added sweeteners, edible oils, and animal-source foods and reduced legumes, other vegetables, and fruits' with the associated adverse health outcomes.[42] There are multiple drivers for this, including income growth, but a recent review concludes that '[t]hese developments are closely linked with the industrialization of food systems, technological change and globalization, including growth in the market and political activities of transnational food corporations and inadequate policies

36 Fukase and Martin (2020), 'Economic growth, convergence, and world food demand and supply'.
37 Nisa, Bélanger, Schumpe and Faller (2019), 'Meta-analysis of randomised controlled trials testing behavioural interventions to promote household action on climate change'.
38 Wohlers, K. (2021), 'Unmasked attendees cut school board meeting short', *Molalla Pioneer*, 10 September 2021, https://pamplinmedia.com/mop/157-news/521394-416571-unmasked-attendees-cut-school-board-meeting-short.
39 Gatten, E. (2021), 'Lecturing meat eaters about climate change not the solution', *Telegraph*, 26 June 2021, https://www.telegraph.co.uk/news/2021/06/26/lecturing-meat-eaters-climate-change-not-solution-says-environment.
40 Tapsfield, J. (2021), ''I don't want extra taxes on hard working people': Boris Johnson slaps down his eating tsar's 'nanny state' call for new tax on sugary and salty food amid fury at the 'madcap' £240 per family plan telling Brits they should be eating ALGAE instead of meat', *Daily Mail*, 15 July 2021, https://www.dailymail.co.uk/news/article-9790837/Fury-nanny-state-meddling-call-tax-sugary-salty-food.html.
41 Clark, A. (2019), 'Behold, the new nanny-free state. Cheap pop for all and no one to say it's bad for us', *Guardian*, 7 July 2019, https://www.theguardian.com/commentisfree/2019/jul/07/if-libertarians-cared-about-give-them-more-control-not-fizy-drinks-sin-taxes-boris-johnson.
42 Popkin, B. M. (2015), 'Nutrition transition and the global diabetes epidemic', *Current Diabetes Reports*, 15(9), pp. 1–8, https://doi.org/10.1007/s11892-015-0631-4.

to protect nutrition in these new contexts'.[43] If it is the case that the industrialization and intensification of agriculture undermine healthy consumption patterns, this weakens the proposition that further intensification could be the main part of the solution of how to feed people healthily. In this case, the economic benefits of increasing the availability of food and reducing prices trade off against the economic costs of worsening public health.

The second critique of the 'diets are difficult to change' argument revolves around whether demand reflects people's preferences. In Version 1's narrative, purchasing patterns are often taken as 'revealed preferences' of consumption patterns. In other words, what consumers buy shows their real, rather than stated, values or attitudes. However, there has been a significant amount of research indicating that consumers often hold much more nuanced attitudes to food, and their purchasing patterns do not necessarily capture their values and beliefs as citizens or family members[44] (contrasting Version 1's view of 'people as consumers' with Version 2's 'people as citizens', as discussed in a 2017 study[45]).

In the UK, several reports reveal commonly held attitudes to food.[46] Most indicate a low public awareness of food-related issues. However, once informed, people tend to say they have increased willingness to change their consumption behaviour, and/or seek reassurances that industry and government are working to reduce risks.[47] The 2013 Which? report *The future of food – giving consumers a say* shows that many citizen jury participants began 'thinking more about where their food has come from and how it has been produced, considering changing the balance of what they eat (e.g. less meat or dairy or more fruit when it is in season) and reducing how much food they waste'. A 2016 report from the UK Food Standards Agency indicated that '[p]articipants were surprised and concerned to realize they knew so little about the complex global food system. There was a strong desire to know more about the processes that bring food to our tables'.[48] It went on: 'Participants […] hoped that the food industry would play a critical role in consumer education, raising awareness of global challenges and empowering consumers to make better decisions about food.'[49]

In terms of food policy, citizens and consumers have a range of concerns about social goods – from provenance and the environmental and air quality impacts of production, to nutrition and price. People place significant trust in regulation and food governance, and have an implicit expectation that their best interests are being properly managed and that the production of food in unsustainable ways –

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43 Baker, P. et al. (2020), 'Ultra-processed foods and the nutrition transition: Global, regional and national trends, food systems transformations and political economy drivers', *Obesity Reviews*, 21(12), https://doi.org/10.1111/obr.13126.
44 Which? (2018), 'Brexit Consumer Research: Topic of focus: food', presentation, 23 May 2018, https://production-which-dashboard.s3.amazonaws.com/system/articles/attachments/1/Brexit_and_Food_April_2018_FINAL.pdf; Food, Farming and Countryside Commission (2022), *Hungry for health*.
45 New Citizenship Project and Food Ethics Council (2017), *Food citizenship: How thinking of ourselves differently can change the future of our food system*, https://drive.google.com/file/d/0B0swicN11uhbSGM2OWdCeXdQZGc/view?resourcekey=0-VH3e9ZMNLMN78bZS_j9zkw.
46 Global Food Security Programme (2012), *Exploring Public Views*, https://www.foodsecurity.ac.uk/publications/global-food-security-programme-exploring-public-views.pdf; Which? (2013), *The future of food – giving consumers a say*, https://www.which.co.uk/policy/food/406/the-future-of-food-giving-consumers-a-say-which-report; UK Food Standards Agency (2016), *Our Food Future*, https://webarchive.nationalarchives.gov.uk/ukgwa/20180411165942/https://www.food.gov.uk/sites/default/files/our-food-future-full-report.pdf.
47 Which? (2013), *The future of food – giving consumers a say*, p. 31.
48 UK Food Standards Agency (2016), *Our Food Future*.
49 Ibid.

or in ways that are detrimental to health – is not promoted through policy and the market.[50] This body of work suggests that there is scope for consumers to modify purchasing based on wider concerns,[51] but that they are currently constrained in doing so by a lack of transparency, habit, and/or the wider food environment affecting choice and convenience of purchasing. Research indicates that consumers are likely to support government policy interventions that pursue a fairer[52] or more sustainable[53] food system if such changes are transparent and if the relevant debates are led by government. Given that price, and Pigouvian taxes,[54] are used to shape a wide range of consumer purchasing decisions (e.g. on alcohol, sugar-sweetened beverages, tobacco and fuel), the potential of shaping food consumption through price change is a subject of current debate.[55] Furthermore, there are many potential levers for influencing food purchasing behaviours from a government perspective, creating structural change in markets. Table 5.6 of the Intergovernmental Panel on Climate Change (IPCC)'s special report on 'Climate Change and Land' (2019)[56] lists about 20 families of policy: from agricultural subsidies and research (to alter the availability of foodstuffs) through changing the food environment (e.g. 'nudges' over placement of goods in store), education and awareness, public procurement, direct transfers of money or food stamps, and planning law (e.g. the placement of fast food outlets). (See also Version 2, Assumption 5.)

Social attitudes have a complex set of determinants, and are themselves subject to non-linear change. Indeed, given certain circumstances, attitudinal and behavioural change can be rapid and significant.

The third critique is that social attitudes have a complex set of determinants, and are themselves subject to non-linear change. Indeed, given certain circumstances, attitudinal and behavioural change can be rapid and significant (as shown during the COVID-19 pandemic). Hence, the perception that, in the recent past, behaviour change has been 'difficult' does not mean that will always be the case. It is possible to imagine plausible combinations of circumstances where social norms change rapidly, opening up the space for rapid change in consumption behaviour. For example, two fires in London's transport network, the first at Oxford Circus station in 1984 and the second, which claimed 31 lives, at King's Cross in 1987, created the political space to start implementing smoking bans in public – initially within

50 Which? (2018), 'Brexit Consumer Research: Topic of focus: food'.
51 Vermeulen, S. J., Park, T., Khoury, C. K. and Béné, C. (2020), 'Changing diets and the transformation of the global food system', *Annals of the New York Academy of Sciences*, 1478(1), p. 3, https://doi.org/10.1111/nyas.14446.
52 Food, Farming and Countryside Commission (2021), 'Shifting the Food System', 12 July 2021, https://ffcc.co.uk/library/shifting-the-food-system.
53 Wellesley, L. and Froggatt, A. (2015), *Changing Climate, Changing Diets: Pathways to Lower Meat Consumption*, Report, London: Royal Institute of International Affairs, https://www.chathamhouse.org/2015/11/changing-climate-changing-diets-pathways-lower-meat-consumption.
54 An additional cost added to the market price, to cover the cost of negative externalities such as health or environmental impacts.
55 National Food Strategy (2021), *The Plan*, https://www.nationalfoodstrategy.org; Funke, F. et al. (2022), 'Is Meat Too Cheap? Towards Optimal Meat Taxation', INET Oxford Working Paper No. 2022-01, https://www.inet.ox.ac.uk/publications/no-2022-01-is-meat-too-cheap-towards-optimal-meat-taxation.
56 Intergovernmental Panel on Climate Change (2019), 'Climate Change and Land'.

the London Underground, then on rail services, then on the bus network – thus accelerating changes in social norms that allowed further bans to be brought in.[57] As significant exposure to climate hazards (extreme weather events, wildfires, emerging diseases, disruption to supply chains and mounting economic costs) makes climate change more tangible to all, this may drive greater consumer-, investor-led or political pressure to find solutions.

Assumption 4: The potential for technology-led 'sustainable' intensification is substantial

Framing: The Version 1 argument suggests that if primacy is given to the market, meeting growing demand and avoiding widespread price increases, it is necessary to innovate to raise supply. As highlighted by Mario Giampietro,[58] the neoclassical economic position is that 'any limiting production factor can be substituted by technological innovation'. Since it is assumed that demand will continue to grow, and given the finite availability of land, this growing demand can only be met through innovation.[59] The predominant frame in international discourse is that investment in agricultural research is key to productivity growth, as was highlighted at COP26 with the launch of the Glasgow Breakthrough Agenda, mobilizing significant money for productivity-enhancing 'sustainable' technologies, including in agriculture.[60] This approach builds on innovation campaigns of the past, including that which gave rise to the so-called 'Green Revolution' of the 1960s.[61] Yields have increased markedly through technological innovation over the past decades, and many argue that there is significant further potential in this respect.[62] For example, analysis of the potential to capture incident radiation indicates a theoretical potential yield for wheat in the UK of 20 tonnes per hectare,[63] compared to the five-year average in 2016–20 of about 8.4 tonnes per hectare.[64]

Critique: First, it is uncertain to what extent intensification can realize productivity gains without an absolute additional environmental impact (to take one example, higher-yielding crops require more nitrogen input, all things being equal,[65] and nitrogen pollution is an issue of increasing environmental concern). It is possible to increase the relative efficiency (in terms of decreasing the environmental impact per kg yielded), but if the yield increases enough, then the absolute impact also increases. Intensification typically leads to a variety of scale-dependent spillover

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57 Action on Smoking and Health (2020), *Key dates in tobacco regulation 1962–2020*, https://ash.org.uk/wp-content/uploads/2020/04/Key-Dates.pdf.
58 Giampietro, M. (2019), 'On the circular bioeconomy and decoupling: implications for sustainable growth', *Ecological Economics*, 162, p. 154, https://doi.org/10.1016/j.ecolecon.2019.05.001.
59 Fukase and Martin (2020), 'Economic growth, convergence, and world food demand and supply'.
60 UK Prime Minister's Office, 10 Downing Street and The Rt Hon Boris Johnson MP (2021), 'World leaders join UK's Glasgow Breakthroughs to speed up affordable clean tech worldwide', press release, 2 November 2021, https://www.gov.uk/government/news/world-leaders-join-uks-glasgow-breakthroughs-to-speed-up-affordable-clean-tech-worldwide.
61 Wright, B. D. (2012), 'Grand missions of agricultural innovation', *Research Policy*, 41(10), pp. 1716–28, https://are.berkeley.edu/~bwright/Wright/Publications_files/Grand%20Missions.pdf.
62 Beddington, J. (2010), 'Food security: contributions from science to a new and greener revolution', *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365(1537), pp. 61–71, https://doi.org/10.1098/rstb.2009.0201.
63 Mitchell, P. L. and Sheehy, J. E. (2018), 'Potential yield of wheat in the United Kingdom: How to reach 20 t ha^{-1}', *Field Crops Research*, 224, pp. 115–25, https://doi.org/10.1016/j.fcr.2018.05.008.
64 UK Department for Environment, Food and Rural Affairs (2020), 'Farming Statistics – final crop areas, yields, livestock populations and agricultural workforce at 1 June 2020 United Kingdom', https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/946161/structure-jun2020final-uk-22dec20.pdf.
65 Mitchell and Sheehy (2018), 'Potential yield of wheat in the United Kingdom'.

effects (due to pollution and landscape homogenization arising from monocultural production[66]). This means that there is no simple linear relationship between environmental impact and the intensity of production: instead, a range of key local thresholds may be encountered, beyond which environmental impacts accelerate. Thus, while intensification is certainly feasible, the degree to which environmental impacts decline absolutely (compared to relatively), and thus the extent to which intensification is truly sustainable at scale, remain debatable.

Second, the technologies required to produce elevated yields are often socially contested – whether these are advanced biotechnological approaches such as gene editing, or wider genetic modification, or impacts on animal welfare (e.g. through increased confinement), or aspects of precision agriculture that have implications for rural labour, data provision and ownership, or unequal access to capital investment.[67] So, technological innovation is a necessary but insufficient step towards scaling that technology into widespread use. What is increasingly recognized is that the technology forms a small part of 'bundles' of social, political and financial innovation that are necessary to take an invention into widespread use, and to navigate the inevitable trade-offs between different dimensions of impact (economic, environmental and social).[68] Furthermore, recent literature emphasizes a lack of 'silver bullet' solutions in this area.[69]

The sustainable intensification literature further emphasizes a number of key points. First, it is claimed that sustainability and intensification should be given equal weighting,[70] whereas operationally they rarely are. The second common assertion is that sustainable intensification applies to the whole system (growing more, sustainably) and that, in some places, de-intensification will be necessary to reduce current environmental impacts.[71] Yet, in practice the discourse more normally centres on raising yields and increasing environmental efficiency, and not on reducing yields and gaining environmental goods. Third, sustainable intensification has three key steps: efficiency gains, a greater substitution of agroecological for synthetic processes, and system redesign for sustainability.[72] Yet the prime focus to date has been on efficiency gains for more profitable agriculture.

Assumption 5: Land sparing is enabled by sustainable intensification

Framing: There is a significant empirical literature that underpins the 'land sparing' approach: that both biodiversity/environmental goods and agricultural production are maximized by separating land for nature from land for agriculture. This separation allows the intensification of agriculture on a smaller area than

66 Fischer, J. et al. (2014), 'Land sparing versus land sharing: moving forward', *Conservation Letters*, 7(3), pp. 149–57, https://doi.org/10.1111/conl.12084; Benton et al. (2021), *Food system impacts on biodiversity loss*.
67 Booth, R. (2021), 'Pathways, targets and temporalities: Analysing English agriculture's net zero futures', *Environment and Planning E: Nature and Space*, 4(1), https://doi.org/10.1177/25148486211064962.
68 Barrett, C. B. et al. (2020), *Socio-Technical Innovation Bundles for Agri-Food Systems Transformation*, Expert Panel Report, Ithaca, NY, and London: Cornell Atkinson Center for Sustainability and Springer Nature, https://hdl.handle.net/10568/110864.
69 Ibid.
70 Garnett et al. (2013), 'Sustainable Intensification in Agriculture: Premises and Policies'.
71 Buckwell et al. (2014), *Sustainable Intensification of European Agriculture*.
72 Pretty et al. (2018), 'Global assessment of agricultural system redesign for sustainable intensification'.

would be the case if land was shared between food production and nature.[73] The 'land sparing + (sustainable intensification)' model is taken to justify the framing that, by (sustainably) intensifying, the pressure on land **will** be reduced, and land **will** (inevitably) be spared.

Critique: While there is a very large literature and evidence base on how sustainable intensification can occur across the scale, from field to farm and to landscape, there is a relative dearth of examples of where intensification has enabled or will enable land sparing,[74] and the degree to which this is regulated and strategic, or is determined by market dynamics. Thus, while the logic of the case is sound and the argument for land sparing is analytically elegant, the evidence of sustainable intensification combined with land sparing on the ground remains weak, because of the need for the governance 'quid pro quo' of protecting land from agricultural expansion while intensifying non-spared land. This situation is exacerbated by the spillover effects of bioenvironmental processes and through the economics of profitability. In the former case, spillovers can occur between intensively farmed land and spared land through, for example, pollution, land fragmentation and microclimatic change, all of which have indirect effects on biodiversity. [75] In terms of profitability, as systems intensify, profits increase and provide an economic incentive to further expand land at the frontier of land conversion (for example, in low-income countries in the tropics).[76] Thus, for sustainable intensification combined with land sparing to be a viable strategy, simultaneous strategies are required, both for the governance and protection of the spared land and for a process of intensification which has minimal environmental impact on the agricultural land. Given the economic incentives
for productivity growth, 'sustainable' intensification has, in many circles, become a synonym primarily for increasing efficiency to favour income. Hence, a sole focus (by government or in agriculture) on increasing the efficiency of production is insufficient to deliver land sparing. As was recommended by one 2014 study, the 'intellectual value' of the 'land sparing vs land sharing' framework should be recognized, '[…] but also its limitations with respect to real-world application'.[77]

Version 1: The ideological underpinnings

Version 1 of sustainable agriculture, in arguing that the future of agriculture will be necessarily based on sustainable intensification and land sparing, makes, implicitly or explicitly, a number of key assumptions. Many of the assumptions rest to a greater extent on ideology than on academic evidence. For example, they give primacy to the notion that consumer demand drives supply to fulfil

73 Reviewed in Balmford (2021), 'Concentrating vs. spreading our footprint: how to meet humanity's needs at least cost to nature'.
74 On this point, please see Thaler, G. M. (2017), 'The land sparing complex: Environmental governance, agricultural intensification, and state building in the Brazilian Amazon', *Annals of the American Association of Geographers*, 107(6), pp. 1424–43, https://doi.org/10.1080/24694452.2017.1309966; Rodriguez García, V., Meyfroidt, P., Gaspart, F. and Kastner, T. (2020), 'Agricultural intensification and land use change: assessing country-level induced intensification, land sparing and rebound effect', Dryad, Dataset, https://doi.org/10.5061/dryad.9zw3r22b8.
75 Didham, R. K. et al. (2015), 'Agricultural intensification exacerbates spillover effects on soil biogeochemistry in adjacent forest remnants', *PLoS ONE*, 10(1), https://doi.org/10.1371/journal.pone.0116474.
76 Byerlee, D., Stevenson, J. and Villoria, N. (2014), 'Does intensification slow crop land expansion or encourage deforestation?', *Global Food Security*, 3(2), pp. 92–98, https://doi.org/10.1016/j.gfs.2014.04.001.
77 Fischer et al. (2014), 'Land sparing versus land sharing: moving forward'.

those demands, a framing that views consumption as revealed preference, which is difficult to change and remains the preserve of the individual consumer. This version does not recognize that existing patterns of consumption are themselves very much the product of decades of deliberative policies interacting with market drivers, shaping individuals' 'food environments', and of a neoliberal, technocratic assumption that investment in technological development will solve the issues (which often permeates both the public and private sectors). Collectively, these can be characterized as, 'If only we let them, markets will solve the problems, and people should be unconstrained in their consumption choices.' While socially led concerns about food regulation – and particularly about the adoption of new approaches, such as genetic modification – are often rejected by politicians and industry as 'being ideological',[78] there is little recognition that giving a market-led framing to the space for solutions to make agriculture more sustainable is itself ideological. Indeed, the Genetic Literacy Project,[79] an agri-biotechnology lobby, labels itself as 'science not ideology' without acknowledging that the drivers for the deployment of the technologies it promotes are very much based on an ideological stance.

78 Neo, P. (2020), "'Stupid and ideological': New Zealand industry rejects anti-GMO group suggestion to establish new food standards authority', FoodNavigator Asia, 20 September 2020, https://www.foodnavigator-asia.com/Article/2020/09/28/Stupid-and-ideological-New-Zealand-industry-rejects-anti-GMO-group-suggestion-to-establish-new-food-standards-authority; Pahpy, L. (2020), 'Viewpoint: Organic food represents a 'reactionary' ideology that doesn't support health or sustainable farming–and should not be subsidized', Genetic Literacy Project, 10 July 2020, https://geneticliteracyproject.org/2020/07/10/viewpoint-organic-food-represents-a-reactionary-ideology-that-doesnt-promote-health-or-sustainable-farming%E2%81%A0-and-should-not-be-subsidized.
79 Genetic Literacy Project (2022), 'Mission, Financial Transparency and Governance', https://geneticliteracyproject.org/mission-financials-governance.

03 Version 2: Agroecology and land sharing

Changing consumption patterns can improve public health and reduce demand. This reduces pressure on land, allowing for the widespread adoption of agroecological farming to make the food system sustainable.

The case made for this version of sustainability

At its core, Version 1 of sustainable agriculture is about how it is assumed that demand for food will inevitably grow. Meeting this increasing demand requires the intensification of land used for agriculture (while working to reduce its environmental impact), without a further expansion of agricultural land. Version 1 gives primacy to the market: discourse is thus typically focused on the supply side, both on growing more and on environmental efficiency (minimizing environmental footprints). There is little engagement with food systems, rather a greater focus on supply chains, often seen as linear and disconnected from their complex webs of interaction. Discourse is rarely about changing what is grown – and how much is needed to be grown – from the perspective of human needs, rather than market requirements. In contrast, Version 2 is more systemic in its framing, linking the demand-side consumption of food to the supply side of agriculture. It recognizes the interconnection of the environmental challenge with the health and nutrition challenge: that diet-related ill-health is now, globally, the single biggest risk factor for ill-health and mortality – primarily through citizens eating too much of the wrong foods and too few health-promoting foods.[80] Furthermore, Version 2's holistic emphasis on food systems incorporates an acknowledgment that a very significant proportion of food is either diverted from human food into livestock feed (globally, 46 per cent of grain destined for the human food system was fed to livestock in 2013)[81] or lost/wasted from 'plough to plate'.[82]

Version 2 suggests that, given that changes in consumption behaviour are necessary to reduce the epidemic of obesity and related diseases,[83] if this is done in alignment with waste reduction and a focus on environmental sustainability, then it could make very significant changes to the demand for food in the future, reducing pressure on land and allowing more sustainable farming practices.[84] In this version, demand is not an exogenous variable set by the market as a simple function of the number of people and the value of their wealth: instead, it is a variable that can be altered, particularly through reducing dietary consumption of foodstuffs whose production has a very large environmental impact. This demand shift can arise, all or in part, through structural change in the market. Rather than being 'market-led', this version is about markets being designed and governed to deliver outcomes for a range of public goods (health- and environment-related as well as economic), while recognizing that there is an upper limit to demand beyond which the latter becomes unsustainable. Within Version 2, people are identified as citizens, not simply consumers, with changing consumption patterns arising from a wide range of systemic changes (in, for example, availability, price, awareness and transparency, as well as food environments) that require changes in governance.[85]

Within Version 2, people are identified as citizens, not simply consumers, with changing consumption patterns arising from a wide range of systemic changes that require changes in governance.

If demand growth is not assumed to inevitably increase, this leads to the question of what the most sustainable agriculture would be, if productivity growth were not at the core of policy and management. Furthermore, if people are incentivized to adopt healthy and sustainable diets, it implies a diversification of agriculture away from a focus on major commodities for processed foods, towards a greater diversity of plants necessary to underpin more flexitarian and plant-based diets.

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80 Springmann, M., Mozaffarian, D., Rosenzweig, C. and Micha, R. (2021), 'Chapter 02: What we eat matters: Health and environmental impacts of diets worldwide', in *2021 Global Nutrition Report: The state of global nutrition*, Bristol, UK: Development Initiatives, https://globalnutritionreport.org/reports/2021-global-nutrition-report/health-and-environmental-impacts-of-diets-worldwide.
81 Our World in Data (undated), 'Cereals allocated to food, animal feed and fuel, World', https://ourworldindata.org/grapher/cereal-distribution-to-uses?country=~OWID_WRL (accessed 12 May 2022).
82 Alexander, P. et al. (2017), 'Losses, inefficiencies and waste in the global food system', *Agricultural Systems*, 153, pp. 190–200, https://doi.org/10.1016/j.agsy.2017.01.014.
83 Swinburn et al. (2019), 'The global syndemic of obesity, undernutrition, and climate change'.
84 Willett, W. et al. (2019), 'Food in the Anthropocene: the EAT–*Lancet* Commission on healthy diets from sustainable food systems', *Lancet*, 393(10170), pp. 447–92, https://doi.org/10.1016/S0140-6736(18)31788-4.
85 National Food Strategy (2021), *The Plan*; Intergovernmental Panel on Climate Change (2019), 'Climate Change and Land', Table 5.6.

Empirical evidence indicates that for many dimensions of sustainability (biodiversity, soil condition, carbon storage and pollution) agroecological approaches, including organic and regenerative farming, have a typically smaller environmental impact at the level of individual farms, in comparison to conventional approaches. Agroecological approaches typically require more complex farming operations (including, for example, land rotation), produce a greater diversity of outputs, and give rise to landscapes that are heterogeneous. This heterogeneity itself supports biodiversity and other ecosystem services. Relaxing the assumption about demand growth reduces the inherent criticism that agroecological approaches are too land-inefficient to 'meet demand' or 'feed the world'.

If people are incentivized to adopt a more diverse, plant-based diet for health purposes, demand for a wide range of vegetables and fruits would rise, and demand for livestock products would fall. If absolute demand falls sufficiently, for example, then even though the relative footprint per kg of product is high, the absolute methane emissions could be low enough to make mixed farming landscapes – where farms are engaged in a mixture of arable and livestock production, and have complex rotations producing a diversity of outputs – systemically feasible.[86] This is because ruminants, while having a relatively large food footprint, may have an overall positive contribution to wider aspects of sustainability if farmed extensively, through (a) consuming grass, (b) nutrient cycling within mixed farming landscapes, and (c) promoting landscape heterogeneity and biodiversity.

With enough demand reduction, land pressure reduces as a whole – as do the incentives to expand the amount of land under agriculture. Under this version, it is therefore imagined possible both to share agricultural land with nature by farming more agroecologically, and to spare natural habitats from destruction – particularly because a significant amount of tropical deforestation is associated with cattle ranching, livestock feed production or oil production – all of which are expected to decline with the adoption of healthier diets.[87]

Within Version 2, technological innovation is perhaps less likely to be aimed at increasing the productivity of crops or livestock, and more likely to centre around delivering improvements in farming systems: shifting to complex, smaller-scale, more circular farming systems. Innovation is also required in the areas of governance and markets, changing regulations to ensure that environmental costs are internalized to the system, modifying market incentives to ensure transparency in health and environmental impacts, and changing consumption behaviours and food environments to stimulate the market 'pull' for healthier and more sustainable diets and reduced waste across the agricultural system.

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86 Schader, C. et al. (2015), 'Impacts of feeding less food-competing feedstuffs to livestock on global food system sustainability', *Journal of the Royal Society Interface*, 12(113), https://doi.org/10.1098/rsif.2015.0891.
87 Willett et al. (2019), 'Food in the Anthropocene'.

Examination of the key assumptions underpinning the framing of Version 2

Given the narrative above, this section will examine the key assumptions underlying Version 2 together with their critiques. Table 3 provides a summary, and is followed by a more detailed discussion of each assumption in turn: these are each subdivided into two sections, headed 'Framing' and 'Critique'.

Table 3. Sustainable agriculture, Version 2: Agroecological approaches with land sharing and sparing, enabled by demand reduction through adopting healthy, sustainable, low-waste food consumption

Key assumptions	Critique
Demand **can** be changed and should be shaped by social needs through regulatory change, leading to structural change in markets.	Demand can change (or be changed), but is difficult, both politically and for reasons related to incumbency.
The current unsustainability of farming is a form of **market failure** that can be corrected.	There are many policy levers that could restructure the market to internalize externalities (see IPCC (2019), special report on 'Climate Change and Land', Table 5.6)[88] but power dynamics and politics make them difficult to deploy.
A **healthy** diet is also a (more) **sustainable** one.	Although this may be the case, it is not necessarily so.
Agroecological approaches can provide sufficient nutrients for healthy diets, without impinging on natural habitat **if consumption patterns change**.	This is possibly true, but it would require very radical structural change in terms of both markets and behaviours, and therefore may be implausible.
Agroecological approaches are **more sustainable** than sustainable intensification.	Like-for-like comparisons show agroecological farming to have less impact at both farm and landscape scale, but the lower relative yield means more land is needed if the same amount is to be produced. Sustainability at the system level is contingent on demand.

Source: Chatham House research.

Assumption 1: Demand can be changed, and should be shaped by social needs

Framing: Given the increasing evidence that existing food systems are unsustainable for health and for the environment, and valuation exercises which show that the total systemic costs outweigh the benefits,[89] there is a growing recognition that dietary change is necessary as a common solution to human and environmental

88 Intergovernmental Panel on Climate Change (2019), 'Climate Change and Land'.
89 Lord, S. (2019), *Valuing the impact of food: Towards practical and comparable monetary valuation of food system impacts*, Oxford: Food System Impact Valuation Initiative, https://foodsivi.org/wp-content/uploads/2020/01/FoodSIVI-Report-Valuing-The-Impact-of-Food-1_2019_12_18.pdf; National Food Strategy (2021), *The Plan*; Benton and Bailey (2019), 'The paradox of productivity'; Willett et al. (2019), 'Food in the Anthropocene'; Swinburn et al. (2019), 'The global syndemic of obesity, undernutrition, and climate change'.

issues (including climate change).[90] Indeed, Version 2 incorporates the assumption that it is of social benefit to redesign food systems to produce health, environmental and social outcomes. In particular, animal-derived foods are responsible for twice the greenhouse gases of plant-based foods[91] and about four times the aggregate land use,[92] yet deliver only 18 per cent of global calories.[93] Changing meat consumption can have very large systemic impacts across health and the environment, especially given that there is a growing evidence base of adverse health-related impacts associated with meat consumption.[94] For example, one study has shown that substituting beans for beef in the US diet could achieve approximately one-half to three-quarters of the greenhouse gas reductions under the 2020 US target.[95] In addition, such a dietary change would free up 42 per cent of US cropland (692,918 square kilometres).[96] Further to the scope for reducing demand for agricultural products through dietary change, food waste is a recognized issue,[97] accounting for up to one-quarter of global calorie production.[98] Given both these issues, there is significant opportunity for changing the pressures on land by making the system more efficient. Focusing on the production of foods that contribute directly to nutrition outcomes, and on reducing the aggregate demand for agricultural production, would require significant structural reform in terms of the market (see Assumption 2, below).

Critique: The first critique of this assumption is based on the perception that demand is difficult to shift (as outlined in Assumption 3 of Version 1). Dietary change of the scale required is very unlikely to occur solely through consumer choice at the point of sale, but rather through structural systemic change that would have to be licensed by citizens' votes (see Assumption 2, below). The creation of sufficient political space to drive systemic change will require changing social attitudes (i.e. the social normalization of the acceptability of change) as well as relaxing some of the assumptions that drive Version 1 (e.g. that economic growth arising from increasing per head consumption of food provides social goods). This may be very difficult to achieve.

The second critique of Assumption 1 rests on the argument that supply is difficult to shift. Given that the global food system is underpinned by increasingly intensive farming systems and substantial capital investments, can the supply side change? This issue is analogous to many debates associated with low-carbon energy and

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90 Willett et al. (2019), 'Food in the Anthropocene'; Global Panel on Agriculture and Food Systems for Nutrition (2020), *Foresight 2.0*, https://www.glopan.org/foresight2; Intergovernmental Panel on Climate Change (2019), 'Climate Change and Land', Table 5.6.
91 Xu et al. (2021), 'Global greenhouse gas emissions from animal-based foods are twice those of plant-based foods'.
92 Ritchie, H. and Roser, M. (2019), 'Land Use', Our World in Data, https://ourworldindata.org/land-use (accessed 4 Dec. 2020).
93 Ibid.
94 Clark, M. A., Springmann, M., Hill, J. and Tilman, D. (2019), 'Multiple health and environmental impacts of foods', *Proceedings of the National Academy of Sciences*, 116(46), pp. 23357–62, https://doi.org/10.1073/pnas.1906908116.
95 Harwatt, H. et al. (2017), 'Substituting beans for beef as a contribution toward US climate change targets', *Climatic Change*, 143, pp. 261–70, https://doi.org/10.1007/s10584-017-1969-1.
96 Ibid.
97 Alexander, P. et al. (2015), 'Drivers for global agricultural land use change: The nexus of diet, population, yield and bioenergy', *Global Environmental Change*, 35, pp. 138–47, https://doi.org/10.1016/j.gloenvcha.2015.08.011.
98 van den Bos Verma, M., de Vreede, L., Achterbosch, T. and Rutten, M. M. (2020), 'Consumers discard a lot more food than widely believed: Estimates of global food waste using an energy gap approach and affluence elasticity of food waste', *PLoS ONE*, 15(2), https://doi.org/10.1371/journal.pone.0228369.

transport systems, including the potential for 'sunken assets'. How feasible is it for livestock farmers to transition out of livestock farming to the degree that Version 2 may imagine? While switching to a plant-rich diet is theoretically feasible, the world currently underproduces fruits and vegetables to a significant degree (perhaps by about two-thirds, in relation to supplying everyone with the internationally recommended five portions a day of fruit and vegetables).[99] Supply-side changes would have to be very substantial to enable this version of sustainability, and incentives would need to change accordingly. The literature suggests that a transition may become more feasible with a 'repurposing of subsidies' to de-risk the social and economic impacts of system change,[100] but this alone is likely to be insufficient due to entrenched social and cultural norms.

There is a commonly expressed opinion that healthy and sustainable diets are typically too expensive to scale to a whole-of-population or global level. Currently, they are indeed too expensive for the poor across the world.

The third critique is that food prices will increase. There is a commonly expressed opinion that healthy and sustainable diets are typically too expensive to scale to a whole-of-population or global level. Currently, they are indeed too expensive for the poor across the world, but especially in low- and middle-income countries.[101, 102] However, this critique may lose some force due to the economics of the market, which suggest that as supply increases, economies of scale reduce prices. A recent analysis of global dietary consumption patterns concludes that a combination of dietary shift (reducing consumption of expensive meat), increasing the scale of fruit and vegetable production, and subsidy reform would mean that overall dietary spending would – for much of the world – reduce upon the adoption of a healthy and sustainable diet.[103] While this may eventually be the case, in the interim a significant increase in social safety nets would be required[104] to avoid rising inequality and food insecurity; this in itself may reduce the plausibility of the assumption.

99 Krishna Bahadur, K. C. et al. (2018), 'When too much isn't enough: Does current food production meet global nutritional needs?', *PloS ONE*, 13(10), https://doi.org/10.1371/journal.pone.0205683.
100 Springmann, M. and Freund, F. (2022), 'Options for reforming agricultural subsidies from health, climate, and economic perspectives', *Nature Communications*, 13(82), pp. 1–7, https://doi.org/10.1038/s41467-021-27645-2.
101 Springmann, M. et al. (2021), 'The global and regional costs of healthy and sustainable dietary patterns: a modelling study', *The Lancet Planetary Health*, 5(11), e797–807, https://doi.org/10.1016/52542-5196(21)00251-5.
102 Hirvonen, K., Bai, Y., Headey, D. and Masters, W. A. (2020), 'Affordability of the EAT–*Lancet* reference diet: a global analysis', *The Lancet Global Health*, 8(1), pp. e59–e66, https://doi.org/10.1016/S2214-109X(19)30447-4.
103 Global Panel on Agriculture and Food Systems for Nutrition (2020), *Foresight 2.0*.
104 Social safety nets are many and varied: they include cash transfers, food subsidies for some or all, or networks of social support at a community level as discussed in Global Panel on Agriculture and Food Systems for Nutrition (2020), *Foresight 2.0*; Food, Farming and Countryside Commission (2021), 'Food Builds Community', 2 July 2021, https://ffcc.co.uk/library/foodbuildscommunity.

Assumption 2: The current unsustainability of farming is a form of market failure that can be corrected

Framing: The current unsustainability of farming represents a form of market failure, in that it allows production costs to be levied on the environment (and on health systems) in unsustainable ways. It thus follows that the market is unlikely to solve the issues, given that they were caused by the market. Instead, there is a need for policy and regulation to create structural change, to reform the market and change the drivers that allow externalization of costs. Indeed, market failure is an often-cited and principal rationale for governments to intervene in markets.[105] Some of the suggested market-shaping interventions that could enable progress towards Version 2 include:

- Reforming agricultural subsidies to reduce environmental and health externalities;[106]
- Investing more public money in research and technology needs for more sustainable agriculture[107] (agroecological research, rotations and farming systems, and a wider focus – on horticulture, rather than on productivity growth in grains and livestock);
- Using the rationale of the 'polluter pays' principle to internalize more environmentally friendly agriculture, and to ensure that environmental standards are enhanced;[108]
- Embedding strong environmental standards into trade agreements;[109]
- Reducing land pressure, by reducing waste and incentivizing low-waste approaches;[110]
- Developing pro-health, system-positive agricultural policy to ensure sustainable nutrition: changing the focus from 'increasing productivity' to 'what should be grown and how?';[111]
- Fully utilizing a range of demand-side measures, such as public procurement, awareness-raising and education, changing the food environment, and using food taxes to shape consumer demand in a pro-health, pro-environmental way.[112] Furthermore, making use of the many existing ways of encouraging

105 Wallis, J. and Dollery, B. (1999), 'Market Failure and Government Intervention', in Wallis, J. and Dollery, B. (1999), *Market Failure, Government Failure, Leadership and Public Policy*, London: Palgrave Macmillan, https://doi.org/10.1057/9780230372962_2.
106 Global Panel on Agriculture and Food Systems for Nutrition (2020), *Foresight 2.0*; Springmann and Freund (2022), 'Options for reforming agricultural subsidies from health, climate, and economic perspectives'.
107 Tittonell, P. A. (2013), *Farming Systems Ecology: Towards ecological intensification of world agriculture*, Wageningen, Netherlands: Wageningen UR, https://edepot.wur.nl/258457.
108 Foote, N. (2021), 'Agri Commissioner backs call for polluter pays principle in farming', Euractiv, 7 July 2021, https://www.euractiv.com/section/agriculture-food/news/agri-commissioner-backs-call-for-polluter-pays-principle-in-farming.
109 National Food Strategy (2021), *The Plan*.
110 Priefer, C., Jörissen, J. and Bräutigam, K.-R. (2016), 'Food waste prevention in Europe – A cause-driven approach to identify the most relevant leverage points for action', *Resources, Conservation and Recycling*, 109, pp. 155–65, https://doi.org/10.1016/j.resconrec.2016.03.004.
111 Global Panel on Agriculture and Food Systems for Nutrition (2020), *Foresight 2.0*.
112 National Food Strategy (2021), *The Plan*; Intergovernmental Panel on Climate Change (2019), 'Climate Change and Land', Table 5.6.

citizen involvement in food system design, particularly at the local level: this includes moving away from seeing people simply as consumers, and moving towards involving citizens in shaping the system;[113] and

— Understanding that, in order to achieve better outcomes for food systems, it might be necessary to address systemic power imbalances,[114] particularly with respect to the consolidated corporate power which may undermine the role of consumer choice to shape the market,[115] and which provides an 'intensification trap' for farmers.[116]

Critique: The principal critique of Assumption 2 in this version is based on the experience gained in attempting other market-shifting transformations – whether these are aimed at reducing harmful tobacco use or at transforming power systems from high-emitting fossil fuel systems to low-emitting systems based on renewable energy. The constraints fall into a number of categories: political will, social will, the will of incumbent market actors to change (and the power they can leverage to maintain the status quo) as well as the plausibility of both the long-term pathway and the end goal. With reference to the energy transition, political will is tempered by all of these issues: if politicians move too fast, changes in price or availability can lead to social unrest (e.g. the *gilets jaunes* [yellow vests] disputes that began in France in late 2018[117]), and economic growth becomes uncompetitive due to the costs of transition. All countries are therefore required to move in step. These issues apply equally in food system transitions, and a single country cannot transform its food system while existing in a liberalized global trading system, as 'sustainable production' in the domestic system will be undermined by imported food produced more cheaply at lower standards.[118] Similarly, the incumbent food industry has strong political and lobbying power which enables it to delay or rebut change.[119] Thus, significant regulatory change is often deemed implausible, because it relies not only on domestic approaches that need to be politically and socially acceptable, but also on the reform of multilateral bodies (for example, of the World Trade Organization – WTO, to enable more sustainable trade).

113 Food Ethics Council (2019), 'Harnessing the power of food citizenship', https://www.foodethicscouncil.org/app/uploads/2019/10/Harnessing-the-power-of-food-citizenship_Food_Ethics_Council_Oct-2019.pdf.
114 Hurst, G. (2021), 'Social Movements And Scientists Are Challenging the UN Food Systems Summit's Agenda', Food Tank, https://foodtank.com/news/2021/09/social-movements-and-scientists-are-challenging-the-un-food-systems-summits-agenda.
115 Lakhani, N., Uteuova, A. and Chang, A. (2021), 'Revealed: the true extent of America's food monopolies, and who pays the price', *Guardian*, 14 July 2021, https://www.theguardian.com/environment/ng-interactive/2021/jul/14/food-monopoly-meals-profits-data-investigation.
116 Tittonell (2013), *Farming Systems Ecology*.
117 Chrisafis, A. (2018), 'Who are the gilets jaunes and what do they want?', *Guardian*, 7 December 2018, https://www.theguardian.com/world/2018/dec/03/who-are-the-gilets-jaunes-and-what-do-they-want.
118 Benton, T. G. et al. (2021), 'A 'net zero' equivalent target is needed to transform food systems', *Nature Food*, 2, pp. 905–06, https://doi.org/10.1038/s43016-021-00434-2.
119 See, for example, on health and health policy: Lauber, K., Rutter, H. and Gilmore, A. B. (2021), 'Big food and the World Health Organization: a qualitative study of industry attempts to influence global-level non-communicable disease policy', *BMJ Global Health*, 6(6), p. e005216, http://dx.doi.org/10.1136/bmjgh-2021-005216; or on agricultural industry pushback: Jacquet, J. (2021), 'The meat industry is doing exactly what Big Oil does to fight climate action', *Washington Post*, 14 May 2021, https://www.washingtonpost.com/outlook/the-meat-industry-is-doing-exactly-what-big-oil-does-to-fight-climate-action/2021/05/14/831e14be-b3fe-11eb-ab43-bebddc5a0f65_story.html.

Assumption 3: A healthy diet is also a (more) sustainable one

Framing: Version 2 implicitly assumes that there is, or can be, alignment between 'healthy' and 'sustainable' food, and that furthermore, the trade-offs between climate-friendly and biodiversity-friendly production can be managed through the extensification of production, enabled through demand contraction arising from the adoption of healthier, lower-impact, diets. While there is a significant debate about what constitutes a healthy diet, and further debate about what constitutes a 'healthy and sustainable diet'[120] (a topic reviewed also in the IPCC's 2019 special report on 'Climate Change and Land'[121]), there is reasonable consensus that there can be alignment between healthy and sustainable diets. The IPCC report concludes:

> In summary, there is significant potential mitigation (high confidence) arising from the adoption of diets in line with dietary recommendations made on the basis of health. These are broadly similar across most countries. These are typically capped by the number of calories and higher in plant based foods, such as vegetables, fruits, whole grains, legumes, nuts and seeds, and lower in animal- sourced foods, fats and sugar. Such diets have the potential to be both more sustainable and healthier than alternative diets (but healthy diets are not necessarily sustainable and vice versa). The extent to which the mitigation potential of dietary choices can be realised requires both climate change and health being considered together. Socio-economic (prices, rebound effects), political, and cultural contexts would require significant consideration to enable this mitigation potential to be realised.[122]

The primary alignment of healthy and sustainable diets is through eating more whole foods and fewer processed foods: the *2021 Global Nutrition Report* states that: 'A healthy diet consists of plenty of fruits, vegetables, legumes, nuts/seeds, whole grains and oils high in unsaturated fats, and little to no red and processed meat, sugar-sweetened beverages, refined grains and oils high in saturated fats.'[123]

Critique: If structural changes in food systems enabled the whole world to eat a diet as defined in Assumption 3 above, the production of fruits and vegetables would need to increase markedly, concurrent with a reduction in grains, oils and sugar – as current food systems focus on yields and calorific, not nutritional, security.[124] This would imply radical changes to the horticultural sector, which could result in either a 'Version 1' global intensification of horticulture and international trade, or a 'Version 2' transition towards more mixed farming systems, where local horticulture is embedded in farming landscapes and there is a move away from monocultures. Thus, while a healthy and sustainable diet, based more on fruits and vegetables and less on animal-derived foods, might support more heterogeneous farming systems with more regionalized supply chains, the robustness of this assumption is weak.

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120 Springmann, M. et al. (2018), 'Health and nutritional aspects of sustainable diet strategies and their association with environmental impacts: a global modelling analysis with country-level detail', *The Lancet Planetary Health*, 2(10), pp. e451–e461, https://doi.org/10.1016/S2542-5196(18)30206-7; Garnett, T. (2014), 'What is a sustainable healthy diet? A discussion paper', Oxford: Food Climate Research Network, https://assets.publishing.service.gov.uk/media/57a089dfe5274a27b20002df/FCRN-sustainable-healthy-diet.pdf.
121 Intergovernmental Panel on Climate Change (2019), 'Climate Change and Land', Table 5.6.
122 Ibid., p. 499.
123 Springmann, Mozaffarian, Rosenzweig and Micha (2021), 'Chapter 02: What we eat matters'.
124 Krishna Bahadur, K. C. et al. (2018), 'When too much isn't enough'.

Assumption 4: Agroecological approaches can provide sufficient nutrients for healthy diets, without impinging on natural habitat

Framing: The assumption is that, if demand were to change – particularly, if there was a reduction in ruminant meat consumption, with its very large land use requirement, and people ate the 'right' amounts of the 'right' crops – and if food waste was reduced, agroecological approaches could 'feed the world'. There is typically a yield penalty[125] for agroecological approaches to farming, which '[ranges] from 5 per cent lower organic yields (rain-fed legumes and perennials on weak-acidic to weak-alkaline soils), 13 per cent lower yields (when best organic practices are used), to 34 per cent lower yields (when the conventional and organic systems are most comparable)'.[126] This means that, all things being equal, more land would be required to produce the amount of food produced today.[127] However, proponents of Version 2 argue that all things would not be equal, because the inefficiencies arising from waste, overconsumption and diets that are out of balance with nutritional needs would, in theory, cause demand for land to decline. At the moment, it is estimated that global production of calories would be sufficient to feed over 10 billion people,[128] but a significant proportion is fed to livestock, which is a form of inefficiency. Thus, by focusing on the efficiency of the system (people being fed healthily and sustainably per unit area),[129] significant land savings are available to compensate for changing farming practices. A recent UK-focused study highlights the co-dependency between land use and diets, in which – assuming significant changes in diets – food produced in an agroecological UK farming sector would release 10 per cent of current agricultural land for nature restoration or other uses.[130]

Critique: Clearly, the proportion of land used for agriculture in any one food system depends both on the specific drivers for that system (e.g. regulation, markets, and international trade liberalization) and the extent to which the demand side is able to tackle waste and overconsumption. As discussed in the critiques of Version 1, how much the demand side can change in order to facilitate changes to agriculture is an open question, and one's individual position in this regard is perhaps based to a significant extent on what one regards as plausible. As summed up in a recent paper by Barbieri et al.,[131] '[f]eeding the world organically would thus require profound adaptations of human diets and animal husbandry'. We are not aware of studies that test the plausibility of demand-side assumptions – arising either from changes in the diets demanded or from structural changes in food systems – in line with the global land use that would be required

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125 Seufert, V., Ramankutty, N. and Foley, J. A. (2012), 'Comparing the yields of organic and conventional agriculture', *Nature*, 485(7397), pp. 229–32, https://doi.org/10.1038/nature11069.
126 Ibid., p. 229.
127 Barbieri, P., Pellerin, S., Seufert, V. and Nesme, T. (2019), 'Changes in crop rotations would impact food production in an organically farmed world', *Nature Sustainability*, 2(5), pp. 378–85, https://doi.org/10.1038/s41893-019-0259-5.
128 Foley, J. A. et al. (2011), 'Solutions for a cultivated planet', *Nature*, 478(7369), pp. 337–42, https://doi.org/10.1038/nature10452.
129 Benton and Bailey (2019), 'The paradox of productivity'; Cassidy, E. A., West, P. C., Gerber, J. S. and Foley, J. A. (2013), 'Redefining agricultural yields: from tonnes to people nourished per hectare', *Environmental Research Letters*, 8(3), https://doi.org/10.1088/1748-9326/8/3/034015.
130 Food, Farming and Countryside Commission (2021), *Farming for Change: Charting a course that works for all*, https://ffcc.co.uk/library/farming-for-change-charting-a-course-that-works-for-all.
131 Barbieri, Pellerin, Seufert and Nesme (2019), 'Changes in crop rotations would impact food production in an organically farmed world', p. 378.

for lower-yielding agroecological approaches; many studies that address this make assumptions that demand will rise (Version 1, Assumption 1) and, therefore, productivity gains in agriculture will be needed.[132]

Assumption 5: Agroecological approaches are more sustainable than 'sustainable' intensification

Framing: There is a very large literature indicating that agroecological approaches can bring more environmental benefits than more intensive, 'conventional' farming.[133] These benefits include improved soils,[134] the reduction of antibiotic usage in livestock farming[135] and increased biodiversity.[136] The latter arises not only from a reduction in intensity, but also from increasing the heterogeneity of the individual farm and the landscape, allowing animals and plants to utilize different habitats at the same time.[137] The picture on water quality and greenhouse gases is more mixed. Some studies suggest water quality (primarily from nutrient leaching) is improved under organic agricultural systems, while others suggest it is worsened. This is likely to be related to the fact that organic fertilizer, if applied at the wrong time, can cause substantial run-off, but can lead to less run-off if incorporated into soils: thus, there is a high degree of context dependency.[138] In the case of greenhouse gases, organic farms often emit less (but they also produce less, so when assessed in terms of greenhouse gas intensity (emissions per kg) they may show similar results).[139] Inevitably, because agroecological approaches involve a lower yield per unit area than more intensive approaches, they need a greater area of land to produce the same weight of food.[140]

'Sustainability' at the farm scale can be measured in multiple ways, given the complexity of agricultural impacts on the environment, and the trade-offs between them.[141] Nevertheless, the assumption that agroecological approaches are 'more sustainable' is empirically testable at the farm level across multiple metrics. The

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132 Willett et al. (2019), 'Food in the Anthropocene'; Alexander, P. et al. (2019), 'Transforming agricultural land use through marginal gains in the food system', *Global Environmental Change*, 57(101932), https://doi.org/10.1016/j.gloenvcha.2019.101932.
133 For a recent review focusing on organic agriculture, see Seufert, V. and Ramankutty, N. (2017), 'Many shades of gray–The context-dependent performance of organic agriculture', *Science Advances*, 3(3), p. e1602638, https://doi.org/10.1126/sciadv.1602638.
134 Reeve, J. R. et al. (2016), 'Chapter Six – Organic Farming, Soil Health, and Food Quality: Considering Possible Links', in Sparks, D. L. (ed.) (2016), *Advances in Agronomy*, 137, pp. 319–67, https://doi.org/10.1016/bs.agron.2015.12.003.
135 Alliance to Save our Antibiotics (2021), *Antibiotic use in organic farming: Lowering use through good husbandry*, https://www.saveourantibiotics.org/media/1914/20210406_antibiotic_use_in_organic_farming.pdf.
136 Gabriel, D., Sait, S. M., Kunin, W. E. and Benton, T. G. (2013), 'Food production vs. biodiversity: comparing organic and conventional agriculture', *Journal of Applied Ecology*, 50(2), pp. 355–64, https://doi.org/10.1111/1365-2664.12035.
137 Gabriel, D. et al. (2010), 'Scale matters: the impact of organic farming on biodiversity at different spatial scales', *Ecology Letters*, 13(7), pp. 858–69, https://doi.org/10.1111/j.1461-0248.2010.01481.x; Dainese, M. et al. (2019), 'A global synthesis reveals biodiversity-mediated benefits for crop production', *Science Advances*, 5(10), p. eaax0121, https://doi.org/10.1126/sciadv.aax0121.
138 Seufert and Ramankutty (2017), 'Many shades of gray–The context-dependent performance of organic agriculture'.
139 Clark, M. and Tilman, D. (2017), 'Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice', *Environmental Research Letters*, 12(6), p. 064016, https://doi.org/10.1088/1748-9326/aa6cd5.
140 Ibid.
141 German, R. N., Thompson, C. E. and Benton, T. G. (2017), 'Relationships among multiple aspects of agriculture's environmental impact and productivity: a meta-analysis to guide sustainable agriculture', *Biological Reviews*, 92(2), pp. 716–38, https://doi.org/10.1111/brv.12251.

evidence has been well reviewed – at least, considering organic agriculture as a suite of agroecological approaches[142] – and, typically, agroecological farming approaches have lower aggregate environmental impacts.

Critique: There are numerous ways in which these conclusions can be open to criticism (e.g. geographical bias according to study location, scale bias – focusing on farms, and ignoring landscape characteristics – and product bias). However, when such biases have been addressed, and like-for-like comparisons made, organic farms are typically better in terms of biodiversity, though the effect varies depending on the plant or animal group under consideration.[143] The sustainability of agroecological approaches at the level of the farm is therefore rather less contested than the observation that a farm producing the same amount of output would need to be, on average, larger than an otherwise identical conventionally intensive farm (and thus relatively land-inefficient). Therefore, the principal critique is that in a world where demand is assumed to grow, land-inefficient production methods require more land in order to produce the amount of food required, with implications for the ability to spare land for nature. Whether agroecological approaches are more 'sustainable' at the system level therefore depends on the extent that demand can change and can accordingly reduce the overall requirement for food.

Version 2: The ideological underpinnings

This version of the linkage between agroecological approaches and food system sustainability rests on ideologies that range from living in better harmony with nature (the notion of stewardship), to reducing the risks to society from crossing planetary boundaries (and variants of 'doomsday-ism').[144] Unlike Version 1, which often sees nature as a form of capital that can be converted into monetary capital, Version 2 can see natural capital as humanity's 'life support', and as both irreplaceable and irreducible.

Conceptually, it may be possible for Version 2 to occur: structural changes to the market would enable demand-side reductions sufficient for the production of enough foods to fulfil nutritional needs from agroecological approaches, while also sharing land with nature. However, in order for that to happen, very significant social, regulatory and thus structural changes would need to take place within food systems. In particular, there is an explicit need to limit consumption to what can be produced sustainably: this need runs counter to the predominant ideology of free-market capitalism, which assumes that supply should be innovated to allow demand to be fulfilled. Rather than putting economic growth at the heart of economic thinking, a more holistic approach would be needed to recognize citizens' well-being[145] as more important (combining, in part, human health benefits and access to a safe and enriching natural environment). Thus, Version 2 requires some 'taming' of current

142 Seufert and Ramankutty (2017), 'Many shades of gray–The context-dependent performance of organic agriculture'; Clark and Tilman (2017), 'Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice'.
143 Gabriel et al. (2010), 'Scale matters: the impact of organic farming on biodiversity at different spatial scales'.
144 Pepper, D. (2002), *Modern Environmentalism: An Introduction*, London: Routledge, https://doi.org/10.4324/9780203412244.
145 Fioramonti, L. et al. (2022), 'Wellbeing economy: An effective paradigm to mainstream post-growth policies?', *Ecological Economics*, 192(107261), https://doi.org/10.1016/j.ecolecon.2021.107261.

visions of capitalism: designing markets to primarily deliver public goods. Markets are crucial to delivering this version of sustainable food systems, but they need to be better structured and governed to ensure equitable outcomes for people and for the planet. Collectively, these outcomes can be characterized as follows: 'If we structure markets better, people will be incentivized to consume in a healthy and sustainable way, and this will enable more nature-positive farming by reductions in demand.'

Version 2 of sustainability is less reliant than Version 1 on technological approaches to boosting yield, but more reliant on holistic farm-system technology development. However, it requires far greater innovation in institutions to underpin radical social change (e.g. in the areas of trade, land and food governance, and social movements).

04 Discussion

Which narrative of sustainable agriculture will be adopted in future – or what combination of the two – will not be determined by their scientific evidence bases. Instead, it will depend on a political and ideological process.

How should policy shape agriculture to make unsustainable food systems more sustainable? Where should investors place their investment in order to drive outcomes that minimize environmental risks? What should civil society support as 'sustainable' choices? How should research funders invest in driving innovation towards sustainability? These are key and contested topics, and not new. By way of illustration, in a debate in the UK House of Lords in 2001, Lord Taverne claimed that: 'there is no sound evidence for saying that organic farming is more environmentally friendly than conventional farming, given its inefficient and wasteful use of land[…]'.[146] Yet, many would claim that organic farming is a more sustainable form of agriculture compared to intensive farming. Should the market support or disincentivize organic farming – or other agroecological approaches – in favour of more productive, but more locally damaging farming systems? These are major questions, with significant ramifications for humans' use of land and for its impacts on the environment and human health.

The aim of this paper was to analyse two narratives for how sustainable agriculture fits within a notion of a sustainable food system. Each narrative is founded to a greater extent on a set of implicit, or more rarely explicit, assumptions, often with a strong ideological basis, than on a scientific evidence base – which has, meanwhile, been extensively reviewed in many reports.[147] The predominant current narrative is Version 1, which is firmly entrenched in political and academic discourse[148] – perhaps so firmly entrenched that proponents take it as inevitable, and either do not question the assumptions, or find it difficult to question them.[149]

146 Hansard HL Deb (2001), 'Organic Farming', Vol 625, 9 May 2001, https://hansard.parliament.uk/lords/2001-05-09/debates/60bf3130-2136-402a-ae18-12cc5d7c8940/OrganicFarming.
147 Global Panel on Agriculture and Food Systems for Nutrition (2020), *Foresight 2.0*, Intergovernmental Panel on Climate Change (2019), 'Climate Change and Land', Table 5.6.
148 Benton et al. (2021), 'A 'net zero' equivalent target is needed to transform food systems'.
149 Hall and Davis (2021), 'Permission to Say "Capitalism": Principles for Critical Social Science Engagement with GGR Research'.

For example, one recent paper has highlighted the need to recognize and analyse the narrative explanations for the functioning of a food system that is based on intensive agriculture:

> The narrative behind this extractive food system ['industrial agriculture'] has not been questioned sufficiently, and alternative narratives of regenerative food systems (e.g., agroecology, food sovereignty) have been framed as incapable of sufficient productivity to sustain world populations or even "anti-science". Yield increases are indeed needed in some regions, especially with growing impacts of the climate emergency; but given the urgency of combatting climate change and socioeconomic impacts of Covid-19, regenerative food production systems that simultaneously sequester more carbon and bring social benefits to poor food producers and their communities are essential and their narrative must be strengthened.[150]

Thus, this paper has contrasted two different models for how agriculture relates to sustainability at the system level. These are somewhat exaggerated in nature, and on balance the future is more likely to see a combination of both Version 1 and Version 2, or a system which occupies the middle ground between the two, rather than an exact interpretation of either. The potential for a mix (with, for example, a certain proportion of farms or regions – or, indeed, of each version – tending more towards one or other end of the spectrum) will probably not be decided with reference to a scientific evidence base. Rather, it will depend on the primacy of the role given to the market and its drivers, and, as such, will be the outcome of a political and ideological process, enabled or disabled by incumbent power relationships and the political economy.

For Version 2 to have a significant role in the future, the market needs to change significantly – including through regulation – to incentivize or otherwise deliver less demand for food overall, but at the same time delivering greater demand for food with the attributes of social and public health goods (i.e. healthier diets and more sustainable production). While this is possible, it runs counter to prevailing ideology: in that it will be perceived to be limiting personal freedom, constraining choice, and creating a 'nanny state'. This transition is thus politically difficult, but not impossible over a timescale of decades (as shown by the range of enabling changes being made to support the energy transition). It is also made more complex in a globally embedded world, as promoting the consumption of 'better diets' has implications for trading relationships – i.e. the issues of standards vs protectionism – overseen by the WTO legal framework of non-discrimination.

Without significant structural change, the inherently market-expanding nature of capitalism is likely to continue to drive up demand through finding new ways to increase the consumption of agricultural products. If this happens, land sparing itself is threatened, as incentives will continue to drive economic spillover effects that would incentivize further deforestation (see the second critique to Version 1, Assumption 1). 'Sustainability' will then be restricted to

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150 Anderson, M. D. and Rivera Ferre, M. G. (2020), 'Unsustainable by design: Extractive narratives of ending hunger and regenerative alternatives', *Current Opinion in Environmental Sustainability*, https://repository.middlebury.edu/islandora/object/oas%3A74.

profit-enhancing efficiency gains and increasingly intensive production framed as 'more for less'. Agroecological approaches will, of course, continue, but will be the preserve of the richest consumers and the poorest farmers, who have less access to capital. In high-income countries, such approaches will thus remain niche.

Beyond market ideology, other factors that may affect version realization inevitably come into play. For example, global geopolitics and climate change impacts, including emergent pests and diseases, might drive increasing volatility, in weather and in the ability to trade, including sourcing fertilizers and other inputs, and accessing markets abroad.[151] These trends may create a focus on the need to enhance resilience within food and trading systems.[152] Further, they could provide incentives for a greater regionalization of supply chains and a greater uptake of agroecological farming, with its enhanced potential for resilience.

To enable more sustainable agriculture and food systems does require changes in governance. These might come from changing citizen attitudes and consumption behaviour, which can politicize the need for change and create the political space for decision-makers to engage. They might also originate in disruptive events that undermine the resilience of the system to such an extent that large-scale change quickly becomes possible.

However they might arise, many changes are urgently needed for food systems to become more healthy and sustainable, to tackle the global health crisis, reduce climate change and combat pollution and biodiversity loss. Such changes are plausible, given the right circumstances and events; whether they are likely is an ongoing debate.

151 Benton, T. G. (2019), 'Using scenario analyses to address the future of food', *EFSA Journal*, 17(S1), p. e170703, https://doi.org/10.2903/j.efsa.2019.e170703.
152 Challinor, A. and Benton, T. G. (2022), 'Technical Report Chapter 7: International Dimensions', in UK Government (2022), *Technical Report of the Third UK Climate Change Risk Assessment (CCRA3)*, UK Climate Risk, https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA3-Chapter-7-FINAL.pdf.

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Acknowledgments

The authors would like to thank Ludivine Rebet and Owen Grafham, both of Chatham House's Environment and Society Programme, for their programme management support; and Sue Pritchard, Jim Scown and Tom Burston at the Food, Farming and Countryside Commission (FFCC) for useful conversations throughout the project. We are very grateful to our anonymous reviewers for their careful interrogation of the paper. We are also grateful to several FFCC staff and research advisory group members for their detailed reviews. The authors are grateful to Vera Chapman Browne for her meticulous and insightful editing of the paper, and for overseeing the production process. Thanks also to Sarah Bunney at Soapbox for her work on the design and production of the paper. Finally, our sincere thanks go to the FFCC for its financial support of this research. The views and conclusions formed and outlined in the paper are the responsibility of the author(s). Both authors were involved in project design. Tim Benton wrote the initial draft, and both authors edited and wrote the final version.

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ISBN 978 1 78413 526 3
DOI 10.55317/9781784135263

Cite this paper: Benton, T. G. and Harwatt, H. (2022), *Sustainable agriculture and food systems: Comparing contrasting and contested versions*, Research Paper, London: Royal Institute of International Affairs, https://doi.org/10.55317/9781784135263

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