2023 Scenathon results

Pathways for food and land-use systems in the United Kingdom

FABLE CONSORTIUM

About FABLE
The Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium is a collaborative initiative to support the development of globally consistent mid-century national food and land-use pathways that could inform policies towards greater sustainability. The Consortium brings together teams of researchers from 24 countries and international partners from the UN Sustainable Development Solutions Network (SDSN), the International Institute for Applied Systems Analysis (IIASA), the Alliance of Bioversity International and CIAT, and the Potsdam Institute for Climate Impact Research (PIK). https://www.fableconsortium.org/

About the authors
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Our food and land-use systems are critical for staying within our planetary boundaries and the Earth's system resilience. Among the six Transformations required to achieve the Sustainable Development Goals (SDGs), the fourth Transformation—focusing on food, land, and water—is crucial. This Transformation is key to achieving SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 15 (Life on Land). Moreover, it significantly supports the remaining SDGs, underscoring its crucial role in fostering a sustainable future.

In this document, we present the results of the 2023 'Scenathon', a modelling exercise by the FABLE Consortium exploring three alternative futures for national and regional food and land-use systems. The term 'Scenathon' stands for 'a marathon of scenarios' and refers to FABLE's iterative process for ensuring that national and regional pathways have coherent trade assumptions and align with global sustainability targets (see the 2024 Sustainable Development Report for more information).

Through these long-term pathways, we can identify trade-offs and synergies between different goals and see the impact of various actions, as well as key levers for guiding sustainable development policies through 2030 and 2050. These results, together with our modelling tools and methods, are designed to support decision-making and the development of better policies and targets to drive the transformation of our food and land-use systems.

Figure 1. Historical share of GHG emissions from Agriculture, Forestry, and Other Land Use (AFOLU) to total AFOLU emissions and removals by source in 2020

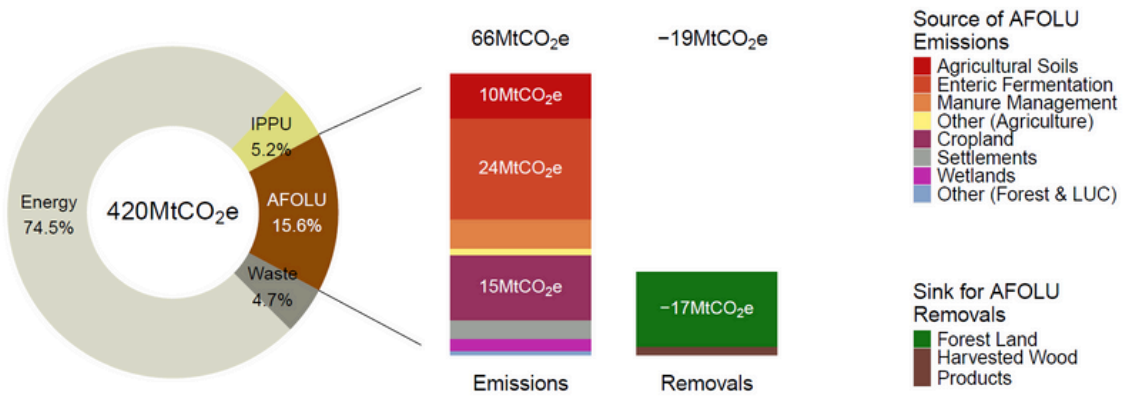
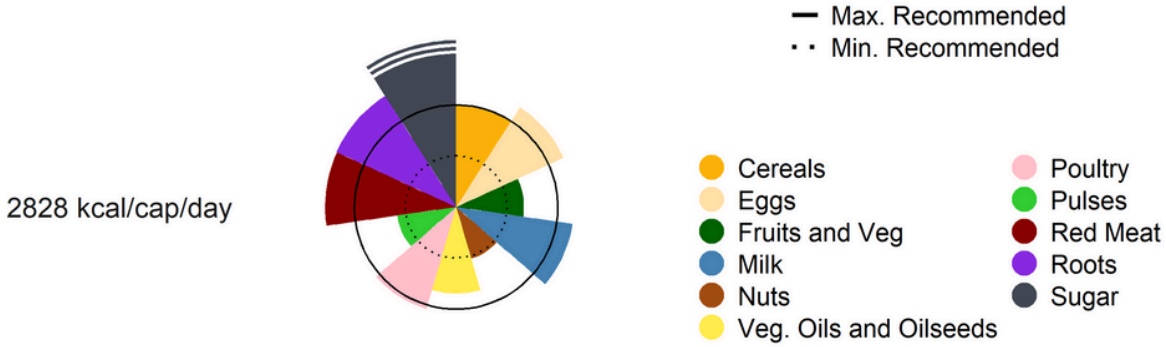


Figure 2. Daily average kilocalorie intake per capital per food category in 2020



National context

UK

This table summarizes national targets for food and land use, derived from national commitments, policies, and strategies. It provides an overview of the country's current ambitions to transform its food and land-use systems. Where countries lacked quantitative national targets, we have estimated targets based on qualitative pledges.

SDG	Indicator	**National Target** (OS) Official source, (A) Assumption by the team.
2 ZERO HUNGER	Overweight / obesity	2573 kcal per cap per day 2050 (A)
	Other food-related targets	50% reduction in food waste by 2030, 60% by 2050 20% reduction in meat and dairy by 2030, 35% reduction in meat by 2050, replaced with plant-based foods. (OS,A)
13 CLIMATE ACTION	Total GHG emissions reduction	Nationwide net-zero by 2050 (OS)
	Land use and land use change GHG emissions reduction	Land-use a net sink of 19Mt CO2e by 2050 (OS)
	Agriculture GHG emissions reduction	CCC Balanced Net-Zero pathway (scenario with some anticipated flexibility in achieving overall net-zero target, no specific agricultural requirement)
	Other climate mitigation targets	390 petajoules domestic bioenergy supply (OS)
15 LIFE ON LAND	Expand protected areas or 'Other effective area-based conservation measures'	30% land protected area by 2030 (OS)
	Promote afforestation	Increase forest area by 31,400 ha/year by 2025, 36,700 ha by 2035 (OS)
	Reduce or halt loss of natural ecosystems	500,000 ha wildlife-rich habitats restored or created by 2043 (OS,A)
	Expand cropland area under agroecological practices	60% farmland has cover crops by 2030, 25% farmland minimum tillage by 2030. (OS,A)
	Other biodiversity related targets	Species extinction risk by 2042 lower than that of 2022. Overall relative species abundance index in 2042 higher than 2022 index + min. 10% higher than 2030 (OS)

Model

Using the open-access FABLE Calculator and the FABLE decentralized modelling infrastructure, we have developed three alternative pathways —Current Trends, National Commitments, and Sustainable Pathway— to explore the impact of various practices and policies on achieving sustainability targets through 2050. We compare our results with targets across food security and nutrition, GHG emissions reduction, forest and biodiversity conservation, and sustainable use of water, nitrogen, and phosphorus.

For each of these pathways, we have established various assumptions regarding the evolution of several model parameters. These parameters include population growth, dietary patterns, food waste, food import and export levels, crop and livestock productivity, agricultural expansion, afforestation, livestock density, protected areas expansion, post-harvest losses, biofuel demand, urban expansion, agricultural practice coverage, and irrigation area expansion. These assumptions detail the extent to which these factors will drive changes in food and land systems from 2020 to 2050.

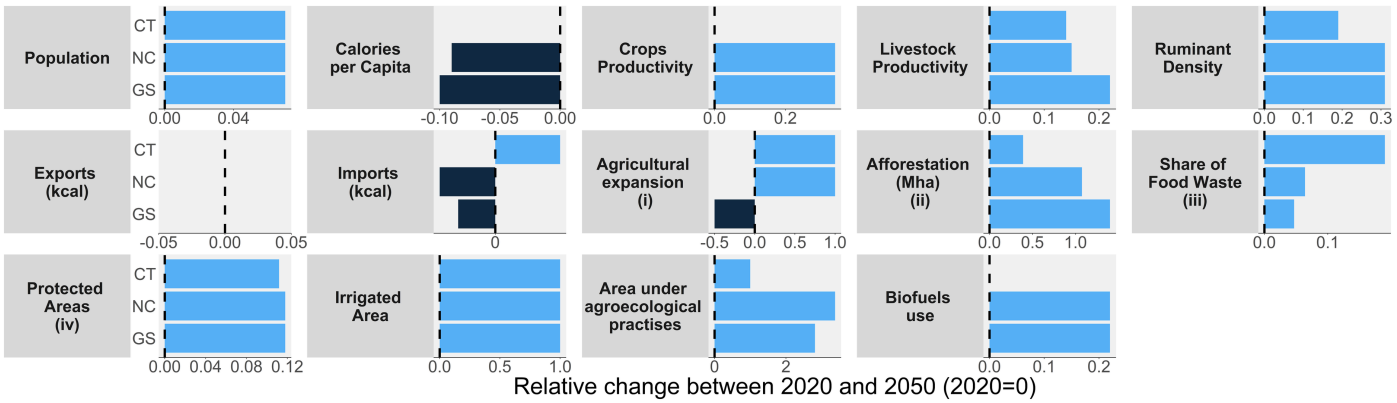
Pathway narratives

Current Trends: This pathway is based on current trends over the last 10 years. Tree planting remains at around 13,000 ha/y, which is 50% broadleaves and 50% conifers. Urban areas increase from 8% to 12% by 2050, based on government housing projections. Around 27% of land area is protected (although, in practice, most of this is managed for landscape rather than biodiversity). Crop yields remain at current levels and milk yield increases by 18% by 2050.

National Commitments: This pathway is based on the Balanced Net Zero pathway developed by the UK Climate Change Committee to meet the national Net Zero target. Tree planting increases to 36,700 hectares per year by 2035. Protected areas increase to 30% of land area, to meet the 30x30 biodiversity target. There are ambitious productivity increases: as well as the 18% increase in milk productivity, crop productivity increases by 34%, livestock stocking density by 10%, and chicken productivity by 10%. Agroecological practices are expanded: cover crops are used on 60% and minimum tillage on 25% of farmland by 2030. Livestock shifts towards grazing on intensively managed grassland. Food waste falls by 60% and diets shift towards plant-based foods, with a 20% fall in dairy consumption and a 35% fall in meat consumption.

Global Sustainability: This pathway is based on the ambitious high-level options developed by the UK Climate Change Committee for delivering Net Zero faster, and also includes stronger actions for biodiversity. Tree-planting increases to 50,000 hectares per year, of which 80% is native broadleaves. Urban development is more compact, taking up only half the area of CT. Half of farmland will be under an ambitious mix of agroecological practices by 2030, including cover crops, embedded natural vegetation and organic farming. Productivity increases are the same as NC, except for milk yield which increases by 27%. There is a shift to grazing on less intensively managed grassland with higher biodiversity. Food waste falls by 70% and meat and dairy consumption are halved.

Figure 3. Assumptions on the levers for change in each pathway



Notes: (i) Results are expressed in code, taking the value 1 for 'Free expansion scenario', -0.5 for 'No deforestation' and -1 for 'No Agricultural expansion'.
(ii) Results are expressed in a net increase rather than relative change.
(iii) Results are expressed % of consumption that is wasted.
(iv) Results are expressed in % of total land in 2050.

Figure 4. Computed daily average intake per capita over 2000-2050

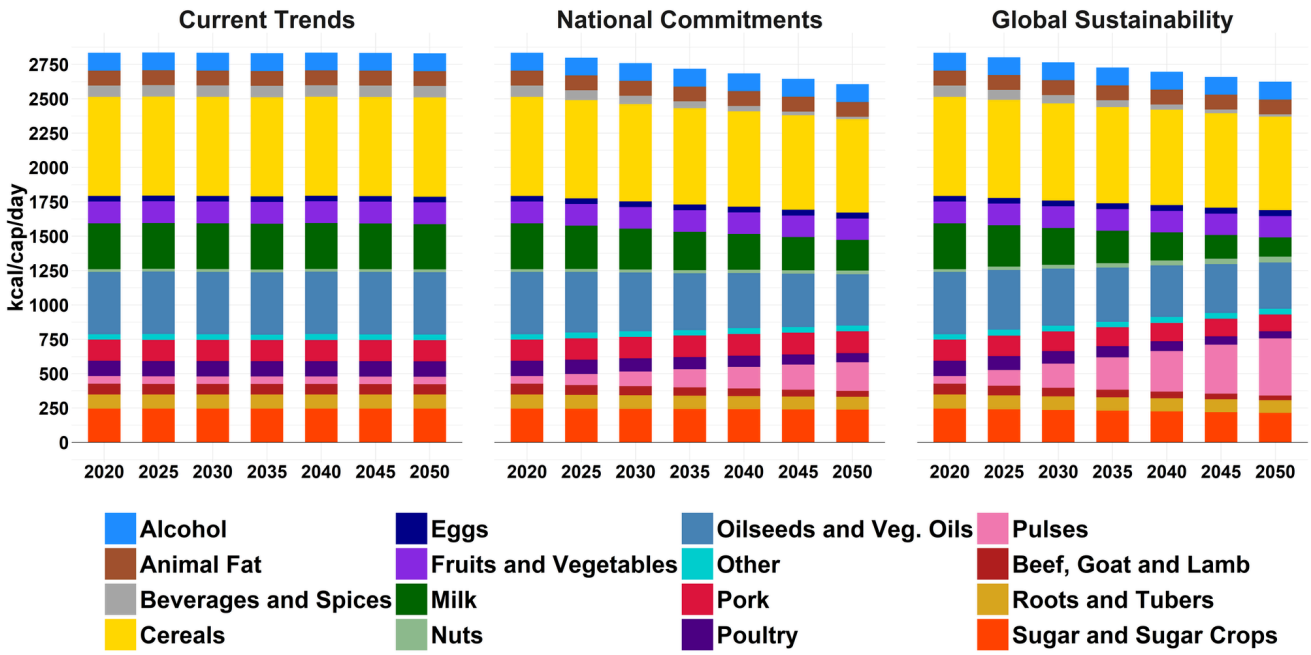


Figure 5. Comparison of the computed daily average kilocalorie intake per capital per food category across the three pathways and the prevalence of undernourishment in 2050

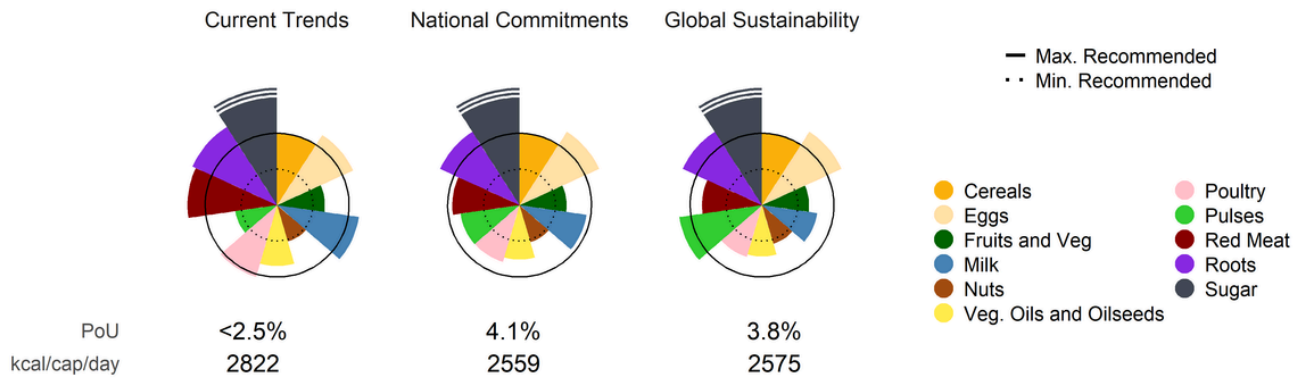


Figure 6. Evolution of land cover 2000-2050

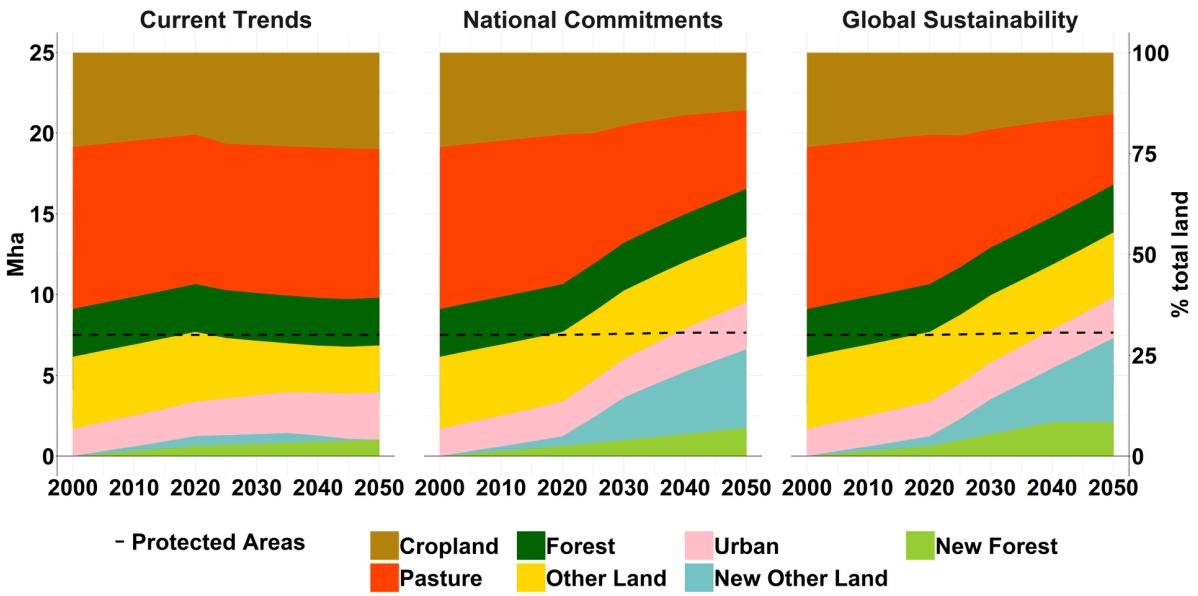


Figure 7. Evolution of the cropland composition 2000-2050

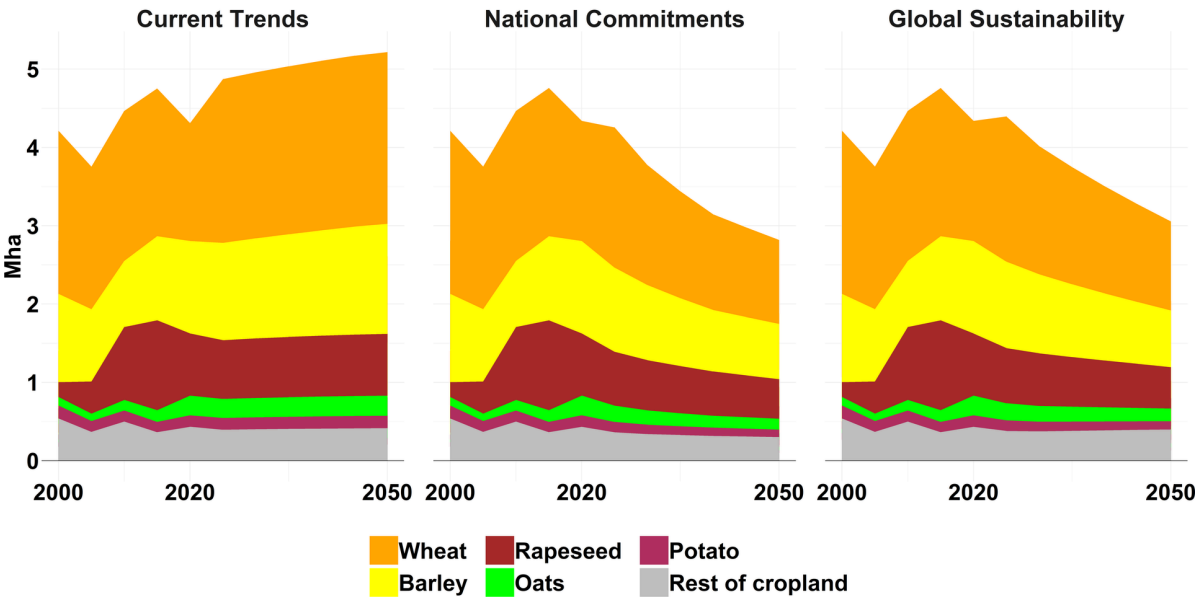


Figure 8. Projected AFOLU emissions and removals between 2020 and 2050 by main sources and sinks across pathways

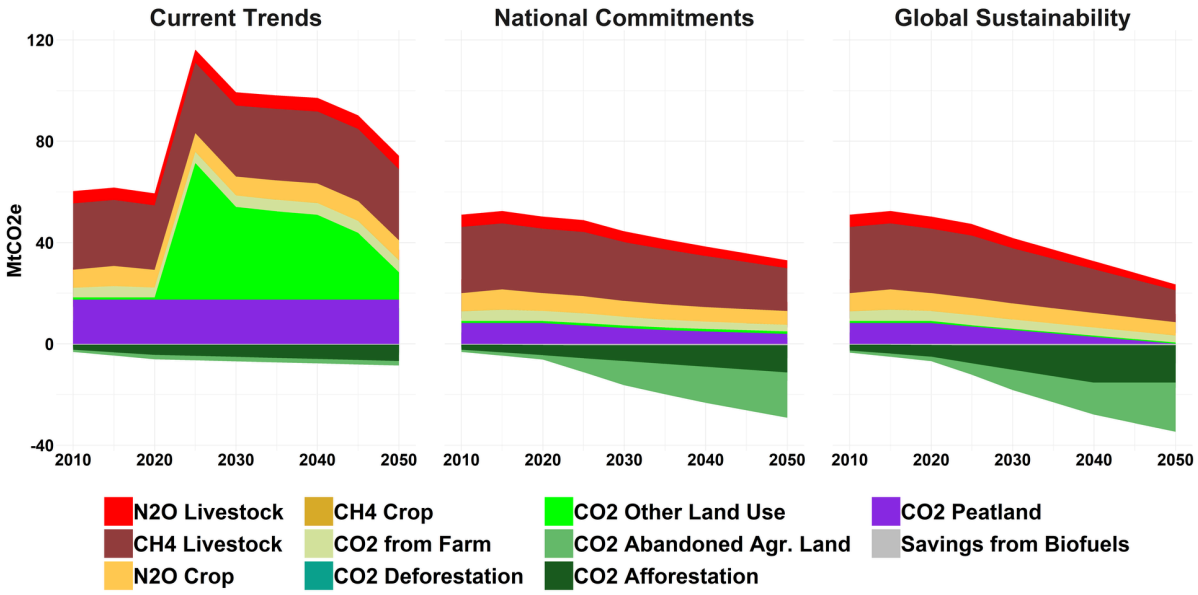
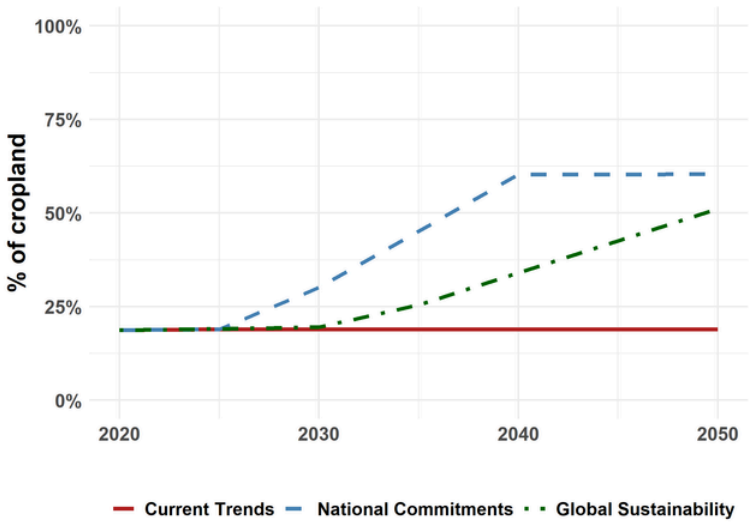


Figure 9. Share of cropland under agroecological practices



Agroecological practices included: Cover crops, cultivar mixtures, diversified farming systems, embedded natural, organic farming, no/minimal tillage

Figure 10. Total area of land where natural processes predominate (LNPP)

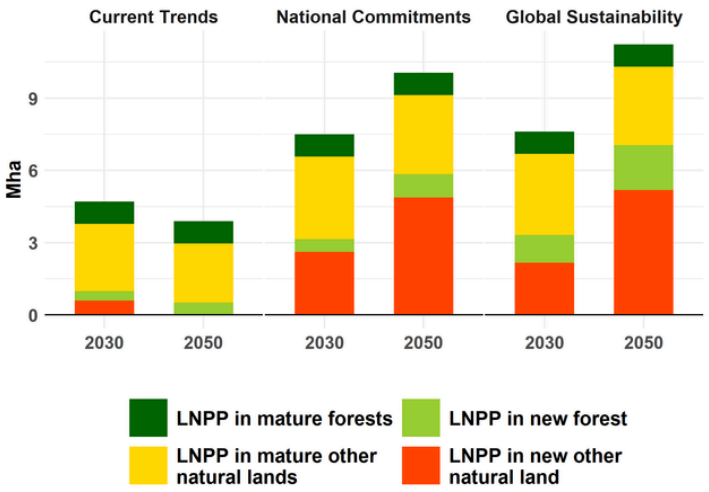


Figure 11. Nitrogen application

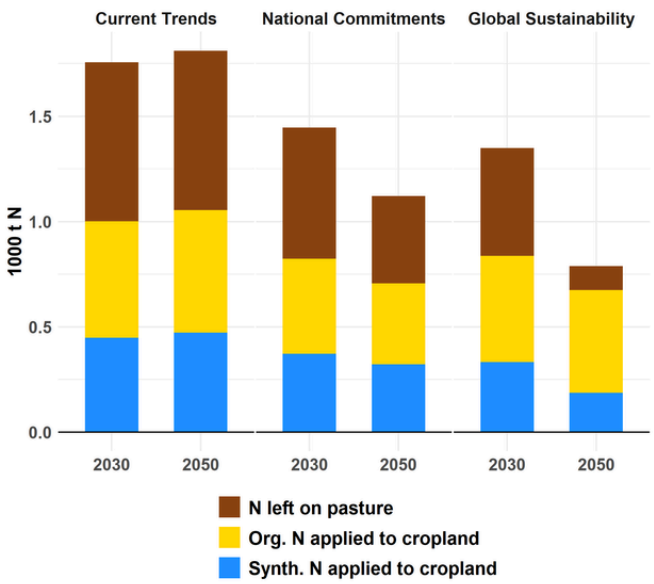
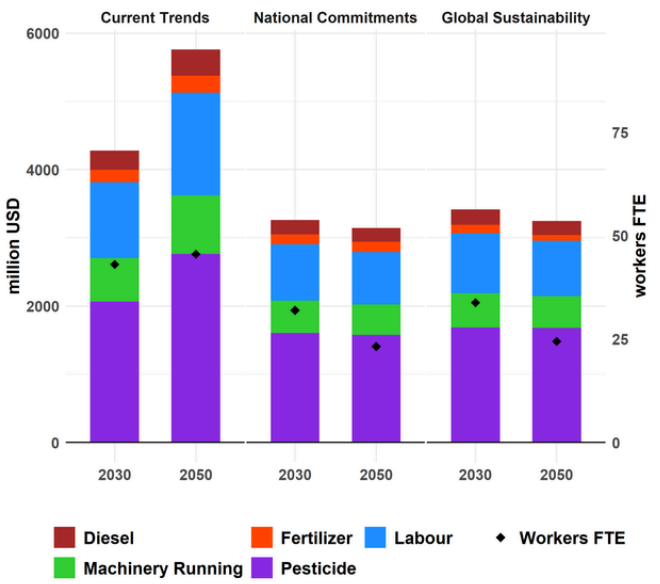


Figure 12. On-farm production costs



FTE: Full-time equivalent

For more detailed results and visual data, visit www.scenathon.org

Recommendations

UK

- **Dietary change** is crucial for achieving Net Zero and biodiversity targets, but to maximise benefits this needs to be a healthy diet not just a low carbon diet. Research in the behavioural, economic, social and political sciences is needed to develop equitable and effective policy levers for dietary change and food waste reduction.

- Major research and investment is needed to optimise **agro-ecological methods** that can increase productivity and soil carbon storage while delivering benefits for biodiversity and ecosystem services.

- UK farmers, growers and producers and their local communities need strong policy support to transition to more sustainable food production and adapt to changing dietary patterns, while **protecting employment, incomes and local culture.**

- **Natural land** should be given more effective **protection** in the planning system, to safeguard carbon stores and biodiversity.

- Housing and infrastructure development strategies should encourage more compact development patterns, avoid loss of high value farmland, and build in a network of **high-quality green infrastructure.**

- Biodiversity, agriculture and forestry policies should consider the impact of **large-scale afforestation** on biodiversity and food production, and focus on restoring a wider range of habitats, using native species or natural regeneration where possible, adopting more sustainable management practices and aligning with nature recovery networks.

- Land use strategies across the four nations of the UK (England, Wales, Scotland and Northern Ireland) need to be **flexible and integrated** so they can be adapted to **local context** and take into account local needs, whilst ensuring the UK collectively meets its international commitments.

- The impact of the UK's ambitious **biofuel targets** needs to be incorporated into the FABLE model.

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
1. Macroeconomics	**1.1)** GDP per capita	SSP2 – middle of the road, medium economic growth	SSP2 – middle of the road, medium economic growth	SSP2 – middle of the road, medium economic growth	No evidence for higher or lower growth, in line with recent trends
	1.2) Population	UN medium projections	UN medium projections	UN medium projections	No evidence for higher or lower growth
	1.3) Inflation	Prices under inflation change based on the average yearly CPI change in the 2000-2020 period	Prices under inflation change based on the average yearly CPI change in the 2000-2020 period	Prices under inflation change based on the average yearly CPI change in the 2000-2020 period	Average. High inflation in the last few months is now falling; future outlook is uncertain.
	1.4) Inequalities				
2. Land	**2.1)** Constraints on agricultural expansion/deforestation	Free expansion	Free expansion	No deforestation	Currently no national policies limit farmland expansion, but this could be necessary under 'Global Sustainability' to achieve global biodiversity targets
	2.2) Afforestation, and forest plantations targets	Remains at **13,000 ha/y** (average observed from 2018-2022, in line with 6th carbon budget baseline) 50:50 broadleaves and conifers in line with current mix (Forestry Commission 2022). Impact of woodland management is not considered as it has a	Increase to **31,400 ha/ year** by 2025 then **36,700 hectares by 2035**. 50:50 broadleaves and conifers as for CT. Sum of individual commitments by England (Environmental Improvement Plan (EIP) target for 12% woodland cover and 16.5% including trees outside	Increase to **30,000 ha/ year** by 2025 then **50,000 hectares by 2035** (BNZ). 80:20 broadleaves to conifers reflecting the need to deliver biodiversity targets as well as climate targets.	See comments in columns

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
		very small impact on emissions (CCC 2020b, Fig 3.6.d).	woodlands, HM Government 2023a); Scotland (18,000 ha/year by 2025; workshop comment); Wales (5000 ha/y 2025-2034, then 7500 ha/y as in FABLE Wales calculator) and N. Ireland (900 ha/y; Forests for Our Future, DAERA 2020). This exceeds the 30000 ha/y target of the UK Net Zero Strategy (HM Government, 2021) but falls short of the BNZ pathway.		
	2.3) Urban and settlements area	Increase from 8% to 12% (over 2.8 m hectares) by 2050, i.e. 26,000 ha/y. Based on CCC (2018) BAU which was based on MHCLG housing projections from 2014. Note: This diverges from the 6CB (CCC 2020b) which now projects an increase from 7% to 9% (14,000 ha/y). The housing targets have not changed but the new	As for current trends	Half of current trends, due to adoption of more compact development patterns i.e. 13,000 ha/y (CCC 2018 high ambition). Note: This diverges from the 6CB (CCC 2020b) where there are now no differences between scenarios, because we want to model the impact of more compact developments.	See text in columns

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
		projections assume more building on green space within settlements (e.g. playing fields). We do not adopt the new projections because this conflicts with the government's Green Infrastructure standards (Natural England, 2023) which reflect the importance of green space for health, well-being and climate change adaptation.			
	2.4) Protected areas	Remains at 6.7Mha (27% of land area), comprising National Parks, AONBs, local and national nature reserves, SSSIs, Ramsar sites and Natura sites (SACs and SPAs), from WDPA database. (Note: 25 new 'King's' nature reserves are planned but not yet identified, and the total area is unknown, though the 221 existing National Nature Reserves add up	Increase to 30% of land area in line with 30x30 target.	Increase to 30% of land area in line with 30x30 target.	Note: the new 2020 protected area dataset contains a higher area of protected areas for the UK than expected, compared to 2010 – we are investigating this.

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
		to only 0.7% of land area).			
3. Productivity and management	**3.1)** Crop productivity for the key crops	Yields remain at current levels (5 year averages 2016-2020): *with climate change (RCP6.0)* **Wheat: 8.0 t/ha** *7.2 t/ha* **Barley: 6.1 t/ha** *5.5 t/ha* **Potatoes: 38.6 t/ha** *35.0 t/ha* Note that current yields are projected to decrease with climate change as suggested by workshop comments.	Between 2020 and 2050, crop productivity increases by **34%**: *with climate change (RCP6.0)* **Wheat: 11.0 t/ha** *10.5 t/ha* **Barley: 8.2 t/ha** **Potatoes: 52 t/ha** BNZ: 30% increase from 8.2 to 11 for wheat, a 30% increase, equivalent to 34% from the 2020 baseline. Same applied to other crops (though this is unrealistic, e.g. potato yield is declining.)	As for NC	Workshop comments suggested that yields used in previous scenathon were too optimistic. Even the yields we now use for this scenathon are considered optimistic by many, despite being in the Climate Change Committee BNZ pathway.
	3.2) Cropland under agroecological practices	No change. Too early to see if ELMS (new agri-environment scheme in England) is promoting additional uptake of measures.	Increase uptake of **cover crops to 60%** of farmland by 2030 (EIP for England, HM Government 2023a; assume same for other DAs) and increase uptake of **minimum tillage to 25%** by 2030. No national targets for reduced tillage and	**50% of farmland under agroecological practices by 2030** (based on CBD post-2020 biodiversity framework target 10 which includes a "substantial" increase in agroecological practices, CBD 2022).	See columns

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
			organic farming - but 75% of farmers in England 'to engage in low carbon practices by 2030, and 85% by 2035' (HM Government 2023b). So minimum is that 15% of farmers adopt one of these other measures by 2030 and 25% by 2035. Assumed to be min-till as that currently received support under ELMS.	Assume this includes a mix of practices: cover crops (50%), embedded natural (50%), organic farming (50%). This is lower than the England target for 85% of farmers adopting low carbon practices, (see NC) but assumes that multiple measures are adopted for GS, in line with the need to deliver both carbon and biodiversity targets.	
	3.3) Livestock productivity for the key livestock products	Assume **milk yield increases by 18%** by 2050 (half the current rate), other yields remain at 2015 levels: • 85 kg/head* for cattle meat, • 13.7 kg/head* for chicken meat, • 7.9 t/head for milk. *Note: units are total annual kg produced	Assume **milk yield increases by 18%** by 2050 (half the current rate) and **chicken yield increases by 10%**; beef remains at 2015 yield: • 85 kg/head for cattle meat, • 15.2 kg/head for chicken meat, • 7.9 t/head for milk (as for CT). BNZ pathway assumes that livestock yield is	Assume **milk yield increases by 27%** by 2050 (75% of the current rate) and **chicken yield increases by 10%;** beef remains at 2015 yield: • 85 kg/head for cattle meat, • 15.2 kg/head for chicken meat, 8.7 t/head for milk	

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
		divided by average herd or flock size at any one time. Hence values differ from carcass weight (e.g. multiple generations of poultry are produced per year).	affected only through increased stocking density (see below). We apply the same 10% increase to chicken, assuming that this can be achieved through improved animal health and breeding.		
	3.4) Pasture stocking rate	Average livestock stocking density remains at 1.1 TLU/ha pasture between 2015 and 2050. TLU = tropical livestock unit (because FABLE is a global model). 1 TLU = 1 cow, 4 pigs, 10 sheep. UK extra feature: % of herd on extensive grassland gradually decreases from 26% to 24% reflecting current trend towards intensification	Average livestock stocking density increases by 10%, from 1.1 to 1.2 TLU/ha pasture between 2015 and 2050 (BNZ). UK extra feature: % of herd on extensive grassland **decreases to 16%** as herd shifts to more intensive grazing (BNZ).	As for NC. Greater increases in stocking density could start to affect other global environmental goals (e.g. water quality, biodiversity). UK extra feature: % of herd on extensive grassland **increases to 30%,** reflecting biodiversity targets.	Workshop comment suggests stocking density could be even higher due to uptake of high-sugar grasses. But BNZ only requires 10% increase.
	3.5) Forest management	Not explicitly modelled as woodland management has a very small impact on emissions (CCC 2020b, Fig 3.6.d).	Not explicitly modelled as woodland management has a very small impact on emissions (CCC 2020b, Fig 3.6.d).	Not explicitly modelled as woodland management has a very small impact on emissions (CCC 2020b, Fig 3.6.d).	

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
4. Trade	**4.1)** Share of consumption which is imported for key imported products (%)	The share of total consumption which is imported stays constant, as assumed in the Government's 6th carbon budget.	The share of total consumption which is imported stays constant, as assumed in the Government's 6th carbon budget.	The share of total consumption which is imported stays constant, as assumed in the Government's 6th carbon budget.	We considered modelling a decrease in imports in products with a large trade gap cap that can be produced indigenously (e.g. vegetables, milk, apples, chicken). However, it may not be possible to increase production for fruit, vegetables and chicken due to a shortage of seasonal migrant labour (AHDB, 2019), and some sources predict a potential increase in imports of beef and chicken (AHDB 2019, EPRA 2018, Hubbard et al 2019).
	4.2) Evolution of exports for key exported products (1000 tons)	The exported quantity stays constant.	The exported quantity stays constant.	The exported quantity stays constant.	Alternatively, key exports could decrease, e.g. for lamb, barley and beef (AHDB 2019; EPRA 2018; Hubbard et al. 2019). Stakeholders consulted in 2020 supported the approach of assuming no change on the grounds that we don't know what will happen.
5. Food	**5.1)** Average dietary composition	No change.	**20% cut in meat and dairy** by 2030, rising to **35% by 2050 for meat only,** to be replaced with plant-based foods (from the BNZ pathway, CCC). Not actually government policy in England, though the National Food Strategy (England) recommends a slightly lower 30% reduction in meat.	**50% cut in meat and dairy by 2050** (6CB High Level). This could entail uptake of lab-grown meat – however this does not need to be explicitly modelled in FABLE (subject to future assumptions about cultured meat crop	**Note:** NC for Wales is Eatwell diet (30% reduction in red meat and 62% reduction in dairy consumption by 2050). Scotland has also adopted Eatwell diet (Scottish Government 2022). This is not yet included in the NC pathway.

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
				feedstock – currently too speculative).	
	5.2) Share of food consumption which is wasted at household level	No change (share of household consumption which is wasted remains at 14%)	50% cut in food waste by 2030 (share of household consumption which is wasted falls from 14% in 2015 to 7%), **60% by 2050** (CCC BNZ).	50% cut in food waste by 2030 (share of household consumption which is wasted falls from 14% in 2015 to 7%), **70% by 2050** (CCC High Level).	Based on CCC BNZ pathway
6. Biofuels	**6.1)** Targets on biofuel and/or other bioenergy use	No increase – remains very low (0.2% of UK arable area in 2016 according to CCC)	**NOT YET IMPLEMENTED – need to add woody biofuels into FABLE.** **30,000 hectares a year by 2035, 0.7 Mha planted by 2050**, evenly split across SRC, miscanthus and SRF. Yield of miscanthus and SRC increases from 12 to **15** oven-dried tonnes/ha by 2050. Yield of poplar SRF remains the same. (BNZ)	**NOT YET IMPLEMENTED – need to add woody biofuels into FABLE.** **1.4 Mha by 2050**. Yield of miscanthus and SRC increases from 12 to **20** oven-dried tonnes/ha by 2050. Yield of poplar remains the same. (CCC High Level)	First generation biofuels (i.e. conventioanl crops: primarily wheat and maize in UK + some sugar beat, oilseed rape, barley) play a limited role in future biomass supply, but 2nd generation short rotation coppice, short rotation forestry and miscanthus expand significantly. These are not directly included in FABLE at present, so we are planning to set up a bespoke implementation in the near future.
	6.2) Targets on other non-food use				
7. Water	**7.1)** Irrigated crop area	No growth – same as in 2010 (about 4%)	No growth – same as in 2010 (about 4%)	No growth – same as in 2010 (about 4%)	Irrigation not widespread and highly crop-specific in UK, and further water abstraction potential is severely limited