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SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK
A GLOBAL INITIATIVE FOR THE UNITED NATIONS

The Food and Land Use Coalition

2019 Report of the FABLE Consortium

Pathways to Sustainable Land-Use and Food Systems

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The full report is available at www.foodandlandusecoalition.org/fableconsortium.
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2019 Report of the FABLE Consortium

Pathways to Sustainable Land-Use and Food Systems in the United Kingdom by 2050

United Kingdom

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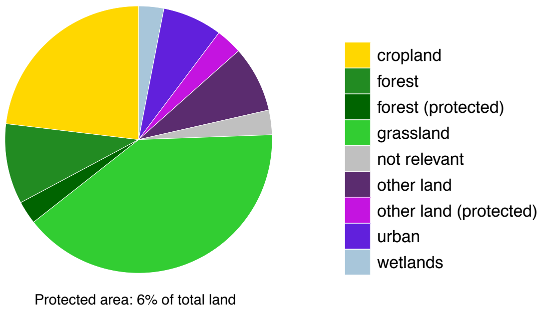
Land and food systems at a glance

A description of all units can be found at the end of this chapter

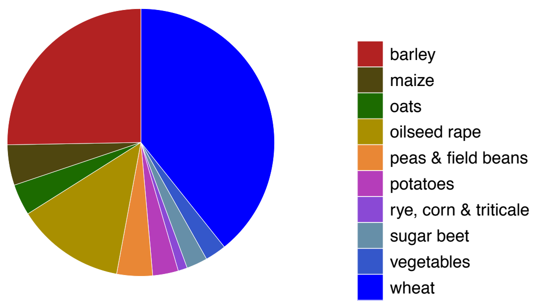
Land & Biodiversity

Fig. 1 | Area by land cover class in 2015



Source: Rowland et al. (2017)

Fig. 2 | Share of harvested area by crop in 2018



Source: Dept. for Environment, Food & Rural Affairs (2018)

No annual deforestation in 2015

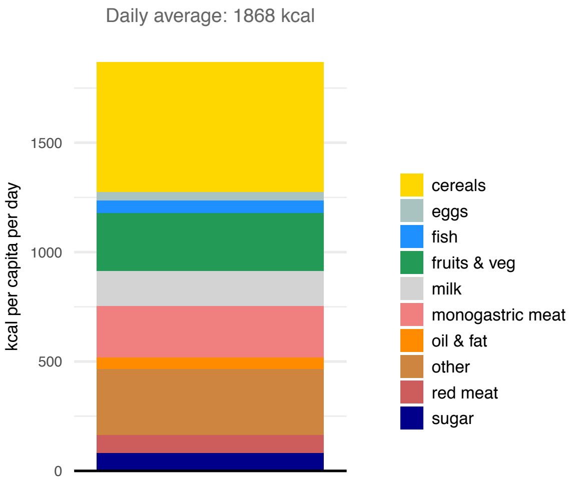
(FAO, 2014)

Endangered species: 108 vulnerable or higher

(IUCN Red List, 2019)

Food & Nutrition

Fig. 3 | Daily average intake per capita at the national level in 2015



Source: Food Standards Agency and Public Health England (2018)

Share of undernourished in 2015: 2.5%

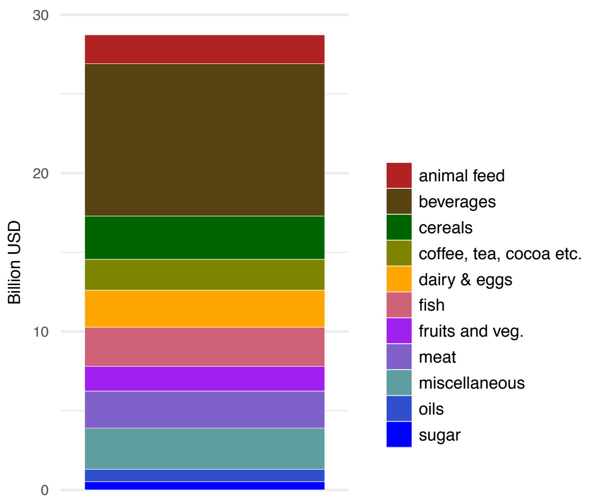
(World Bank, 2019)

Share of obese in 2017: 29%

(NHS, 2019)

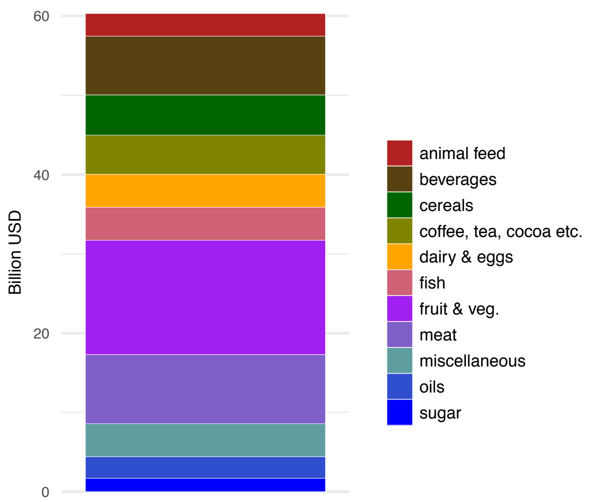
Trade

Fig. 4 | Main agricultural exports by value in 2017



Source: HMRC (2017)

Fig. 5 | Main agricultural imports by value in 2015



Source: HMRC (2017)

Deficit in agricultural trade balance in 2017: USD 18.5 bln

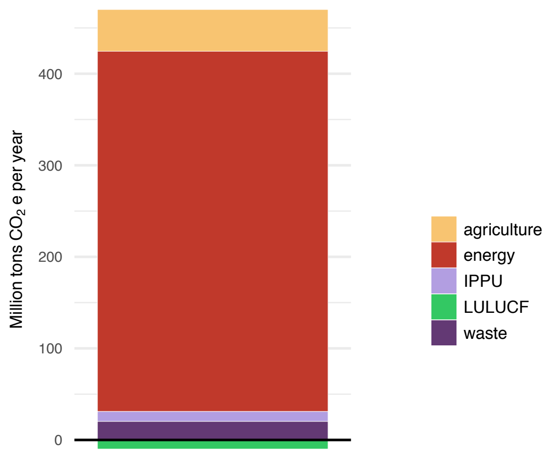
(DEFRA, 2017)

5th most important importer in the world in 2015

(FAOSTAT, 2019)

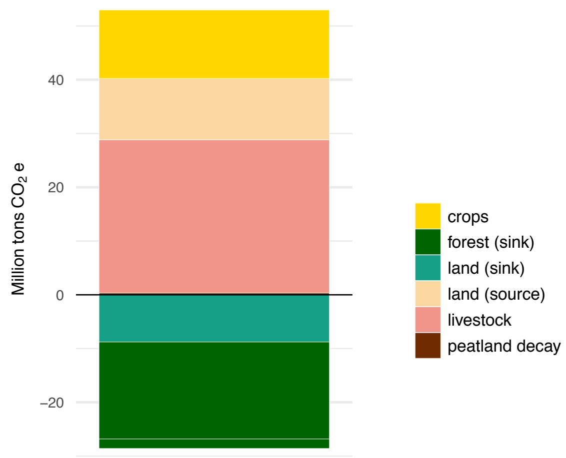
GHG Emissions

Fig. 6 | GHG emissions by sector in 2017



Source: Dept. for Business, Energy & Industrial Strategy (2019)

Fig. 7 | GHG emissions from agriculture and land use change in 2015



Source: Dept. for Business, Energy & Industrial Strategy (2019)

Main assumptions underlying the pathway towards sustainable land-use and food systems

For a detailed explanation of the underlying methodology of the FABLE Calculator, trade adjustment, and envelope analysis, please refer to sections 3.2: Data and tools for pathways towards sustainable land-use and food systems, and 3.3: Developing national pathways consistent with global objectives.

GDP GROWTH & POPULATION

	GDP per capita	Population
Scenario definition	GDP per capita is expected to increase by 135% from USD 41,440 in 2015 to USD 97,530 in 2050 (SSP2 scenario selected).	The population is expected to increase by 15% between 2015 and 2050 from 65.4 mln to 75.4 mln (UN Medium growth scenario selected).
Scenario justification	This is based on an annual 2.5% growth rate in GDP, similar to the predictions made by PwC in their report (PWC, 2017).	This is similar to the predictions on UK population from the UN and Office of National Statistics (Office for National Statistics, 2017; UNDESA, 2017).

TRADE

	Imports	Exports
Scenario definition	The share of total consumption which is imported: - decreases by 50% for milk and orange between 2010 and 2050 (e.g. from 17% to 9% for milk), - remains constant for the other products.	The exported quantity remains constant.
Scenario justification	Based on the Government's Agriculture policy statement that there is opportunity for the UK to import less food (House of Lords, 2018).	Imports are reduced by increasing production rather than by reducing export quantities.

Scenario signs no change small change large change

LAND

	Land conversion	Afforestation (large change)
Scenario definition	We assume that there will be no constraint on the expansion of the agricultural land beyond existing protected areas and under the total land boundary.	We assume a high level of afforestation with a total targeted afforested area of 1.7 Mha by 2050.
Scenario justification	Currently, there is no effort that we are aware of aiming to limit agricultural land expansion. This will critically depend on the replacement of the EU Common Agricultural Policy following the UK's exit from the EU. However, the Committee on Climate Change's (CCC) Land Use Report proposes that land needs to be released from agricultural production to reduce GHG emissions. It should be noted that the other driver assumptions mean that this assumption plays no role in the final results (as productive land declines) (Committee on Climate Change, 2018).	Based on CCC Land Use Report, which assumes a high ambition scenario with an annual forest planting rate of 50kha/year, which "exceeds historic afforestation levels, but is not far off the levels achieved in 1971" (Committee on Climate Change, 2018).

BIODIVERSITY

	Protected areas (no change)
Scenario definition	The protected areas remain constant at 1.5 Mha between 2015 and 2050.
Scenario justification	Based on recent trends of terrestrial protected areas (DEFRA, 2018c).

Scenario signs = no change → small change ↗ large change

FOOD

	Diet (large change)	Food waste (large change)
Scenario definition	Between 2015 and 2050, the average daily calorie consumption per capita decreases from 2,704 kcal to 2,590 kcal. Per capita consumption: - increases by 5% for pig and poultry meat, - decreases by 46% for milk, - increases by 33% for eggs, - increases by 622% for pulses, - decreases by 48% for ruminant meat, - increases by 18% for cereals, - increases by 10% for fruits and vegetables, - decreases by 28% for oilseeds, - increases by 26% for roots, - decreases by 68% for sugar.	Between 2015 and 2050, the share of household consumption which is wasted decreases from 10% to 5%.
Scenario justification	Based on the Eatwell guide (2016), which defines the government's recommendations on eating healthily and achieving a balanced diet. This is the dietary assumption behind the CCC Land Use Report (Committee on Climate Change, 2018).	Based on the CCC Land Use Report's high ambition scenario (Committee on Climate Change, 2018).

PRODUCTIVITY

	Crop productivity (large change)	Livestock productivity (small change)	Pasture stocking rate (large change)
Scenario definition	Between 2015 and 2050, crop productivity increases: - from 7.9 t/ha to 15.4 t/ha for wheat, - from 45 t/ha to 88 t/ha for potato.	Between 2015 and 2050, the productivity per head increases: - from 111.7 kg/head to 126.4 kg/head for cattle meat, - from 1.37 kg/head to 1.44 kg/head for chicken meat, - from 8.8 t/head to 10 t/head for cattle milk.	The average livestock stocking density increases from 1.31 TLU/ha to 1.66 TLU/ha pasture between 2015 and 2050.
Scenario justification	Based on the CCC Land Use Report's high ambition scenario for GHG emissions reduction, due to advances in technology, improvements in farming efficiency and plant breeding. This is less ambitious in timescale than the very high ambition target of Rothamsted Research's 20:20 Wheat Programme (Rothamsted Research, 2017), which aims to double the UK's wheat yields by 2032 (Committee on Climate Change, 2018).	Based on the qualitative assessment of the text regarding improvements in productivity of agriculture in the CCC Land Use Report, through better health of animals, as well as breeding and grazing practices (Committee on Climate Change, 2018).	Based on the CCC Land Use Report's high ambition scenario, in which livestock density increases by 50% (Committee on Climate Change, 2018).

Scenario signs no change small change large change

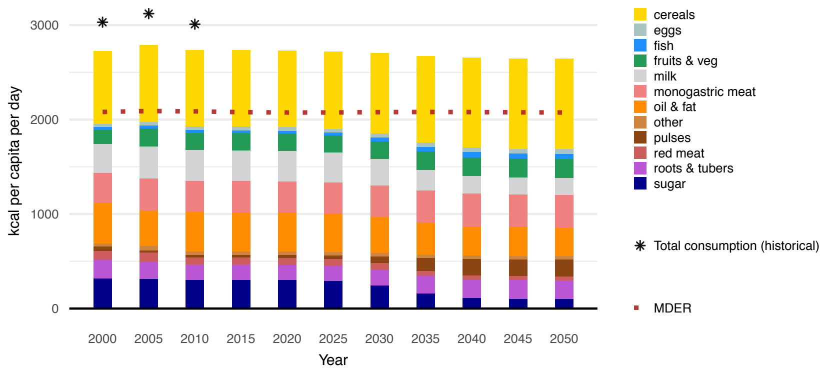
Results against the FABLE targets

The results for FABLE targets as well as "other results" are based on calculations before global trade harmonization.

Food security

Fig. 8 | Computed daily average intake per capita over 2000-2050

Note: The Minimum Daily Energy Requirement (MDER) is computed based on the projected age and sex structure of the population and the minimum energy requirements by age and sex for a moderate activity level. Animal fat, offal, honey, and alcohol are not taken into account in the computed intake.



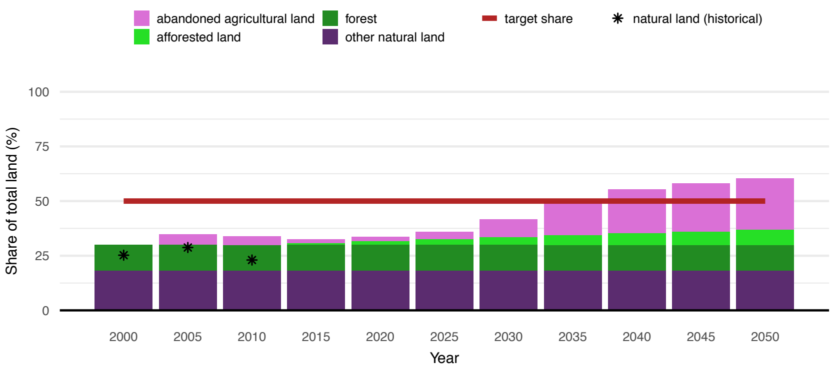
Historical data source: FAOSTAT (2019)

Our results show that average daily energy intake per capita increases between 2,696 and 2,704 kcal/cap/day from 2000-2015. This is 11% lower than FAOSTAT due to some products not being taken into account in our calculation. Over the last decade, 29% of the food intake came from cereals. Calorie intake reaches 2,625 over the period 2031-2035 and 2,590 kcal/cap/day over the period 2046-2050.

In terms of recommended diet, our results show higher consumption of pulses and cereals and lower consumption of ruminant meat and sugar. The computed average calorie intake is 20% higher than the Minimum Dietary Energy Requirement (MDER) at the national level in 2050.

Biodiversity

Fig. 9 | Computed share of the total land which could support biodiversity over 2000-2050



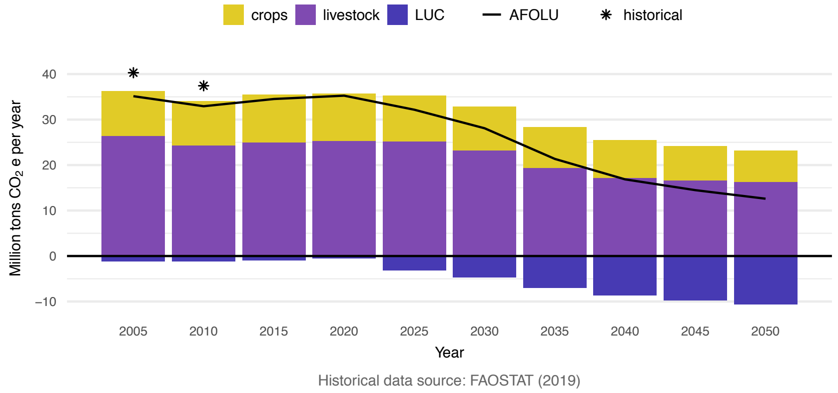
Historical data source: FAOSTAT (2019)

Our results show that the Share of Land which can support Biodiversity (SLB) decreased between 2000-2015 from 36% to 34%. This number is higher than estimates based on CEH Land Cover Map statistics (Rowland et al., 2017). The lowest SLB is computed for the period 2011-2015 at 34% of total land. SLB reaches 62% over the last period of simulation, 2046-2050. The difference is explained by higher afforestation and conversion to the other land class.

Compared to the global target of having at least 50% SLB by 2050, our results are above the target. Our results are consistent with national biodiversity objectives of halving the rate of loss of natural habitats by 2020, or where possible, reducing the loss to zero.

GHG emissions

Fig. 10 | Computed GHG emissions from land and agriculture over 2000-2050



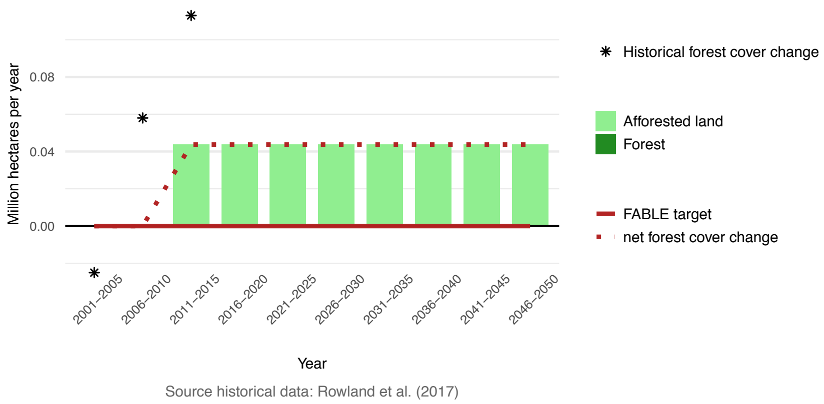
Note: AFOLU (Agriculture, Forestry and Other Land Use) is the sum of computed GHG emissions from crops, livestock and Land Use Change (LUC), emissions and sequestration from forestry are not included. Historical emissions include crops and livestock.

Our results show annual GHG emissions between 42 and 33 Mt CO_2e/year over 2000-2015 which decrease over time. These are similar to FAO, which estimates a maximum of 44 Mt CO_2e/year over the same period with a decreasing trend. Peak AFOLU GHG emissions are computed in 2000 at 42 Mt CO_2e/year. This is mostly driven by GHG emissions from livestock. AFOLU GHG emissions reach 13 Mt CO_2e over the period 2046-2050: 17 Mt from agriculture and -4 Mt from LULUCF. Negative net emissions from LULUCF by 2050 are mainly explained by afforestation.

Compared to the global target of reducing emissions from agriculture and reaching zero or negative GHG emissions from LULUCF by 2050, our results are above the target. Our results show that AFOLU could contribute to as much as 30% of the total GHG emissions reduction objective of the UK.

Forests

Fig. 11 | Computed forest cover change over 2000-2050



There is no deforestation computed in our results from 2000-2015. This is consistent with the FAO Global Forest Resources Assessment. Afforestation is computed from 2015-2050 and leads to a positive net forest cover change over 1.7 Mha.

Compared to the global target of having zero or positive net forest change after 2030, our results are above the target. Our results meet national objectives of having increased net forest cover change by 2060 at 5 kha/year (House of Commons, 2017).

Other relevant results for national objectives

Table 1 | Other Results

Variable	Unit	2000	2005	2010	2015	2020	2030	2040	2050
Wheat									
Production (historical)	Mt	16.7	14.9	14.9					
Production (calculated)	Mt	16.6	13.9	14.7	16.4	16.8	17.6	18.5	19.0
Beef									
Production (historical)	kt	705	762	908					
Production (calculated)	kt	698	742	845	870	887	801	541	518
Land cover									
Cropland (historical)	Mha	5.8	6.1	6.1	5.7				
Cropland (calculated)	Mha	5.8	5.4	5.5	5.8	5.7	5.4	4.8	4.1
Pasture (historical)	Mha	10.0	9.7	9.6	9.8				
Pasture (calculated)	Mha	9.8	9.0	9.1	9.0	8.8	7.2	4.4	3.7
Urban (historical)	Mha	1.7	1.5	1.6	1.8				
Urban (calculated)	Mha	1.7	1.7	1.7	1.7	1.7	1.8	1.8	1.8
Forest (historical)	Mha	2.9	2.9	2.9	3.1				
Forest (calculated)	Mha	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Afforestated land (calculated)	Mha	0.0	0.0	0.0	0.2	0.4	0.9	1.3	1.8
Other land (historical)	Mha	4.3	4.5	4.4	4.2				
Other land (calculated)	Mha	4.5	5.7	5.5	5.0	5.1	6.5	9.5	10.3

Source of historical data: FAOSTAT for production, CEH LCM for land cover

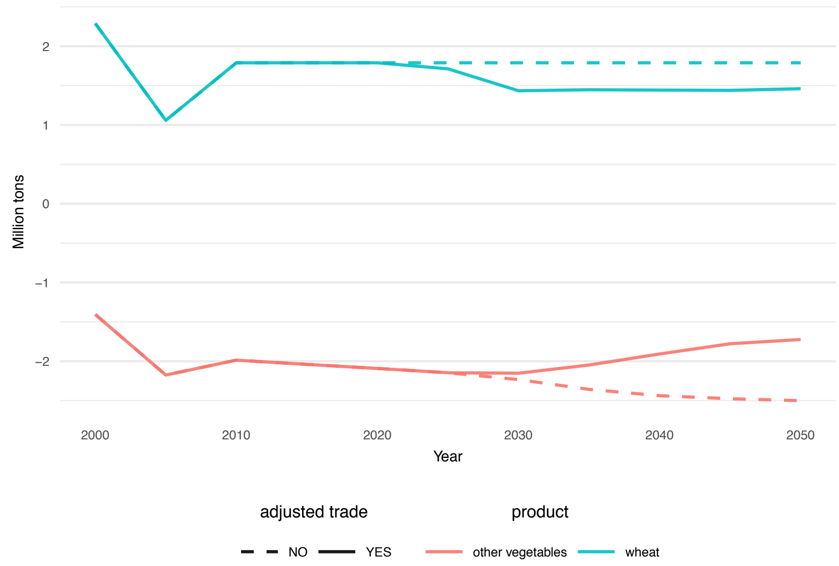
Historical wheat production has fluctuated about a mean quantity of around 15 Mt, which is matched well by the Calculator. Our results suggest that wheat production will increase overall given the scenario assumptions made. This is due to a balance between a reduction in cropland and an increase in yield over the model integration.

The Calculator matches historical beef production data well, as both FAOSTAT (2019) and the Office for National Statistics (2019) indicate a growth from around 700 kt to 900 kt between 2000 and 2015. Beef production decreases over the next 35 years, driven by the shift away from a meat-based to a plant-based diet. The reduction in production is not as severe as the change in pasture land cover would imply due to an increase in both livestock productivity and stocking density.

The Calculator generally matches the historical trends well. We see large changes away from productive land to "other land" and new forest. This is consistent with the high ambition scenario of the CCC Land Use Report (Committee on Climate Change, 2018).

Impacts of trade adjustment to ensure global trade balance

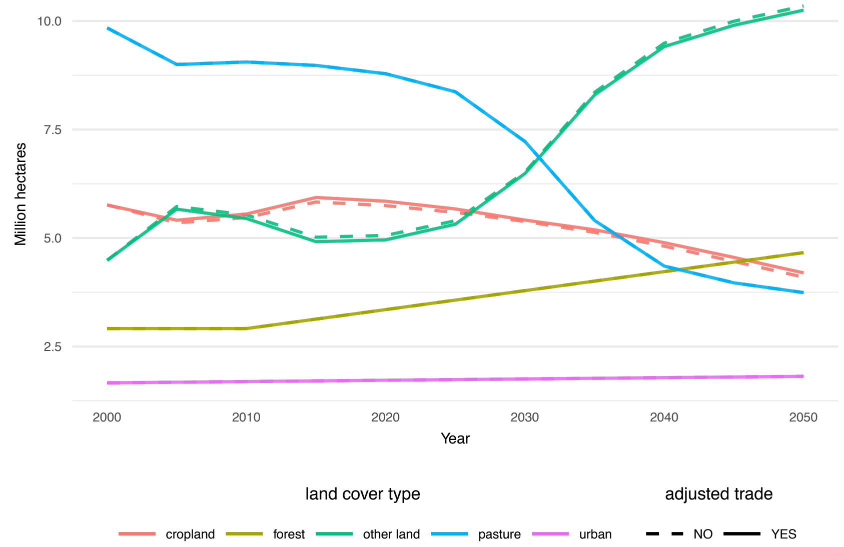
Fig. 12 | Impact of global trade harmonization on main exported/imported commodities over 2000-2050



The impact of the trade adjustment on wheat exports is to reduce them to a lower, but still stable, value (around 350 kt lower). Barley exports show no changes at the start or end of the pathway but dip in the middle, rather than staying stable, when the trade adjustment is applied.

Other vegetable imports increase in the future to 2.5 Mt in 2050 if trade adjustments are not included and are reduced to around 1.7 Mt if they are.

Fig. 13 | Impact of global trade harmonization on land use over 2000-2050



There is very little difference between the changes in land cover with and without adjusting trade.

Discussion and next steps

The UK government recognizes that the current approach to land use is not sustainable and that there is now an opportunity to define a better land strategy that responds fully to the challenge of climate change and delivers environmental quality and a full range of ecosystem services. The Government's 25-year Environment Plan, Agriculture Bill and proposed Environment Bill (DEFRA, 2018a, 2019; House of Commons, 2018) will set the future direction of policy for the use of land. The Department of Environment, Food and Rural Affairs has also commissioned a review to frame a UK Food Strategy. Meeting the target in the UK Climate Change Act (UK Government, 2008) to reduce emissions by at least 80% of 1990 levels by 2050 will require existing progress in the land use sector to be supplemented by more ambitious measures (Committee on Climate Change, 2015). The existing policy framework involves an industry-led voluntary approach to emissions reduction in agriculture, combined with an afforestation target to plant 27,000 hectares per annum across the UK by 2030. This approach is insufficient to meet the ambition set out in the Committee on Climate Change's trajectory to meet the fifth carbon budget (Committee on Climate Change, 2018). Given the recent announcement by the UK Prime Minister to further enhance this target to net zero greenhouse gas emissions by 2050 (Committee on Climate Change, 2019), it is essential that the key objectives of the Climate Change Act (2008) (achieving deep emissions reduction and adapting to the impact of a changing climate) are at the heart of the land use reforms.

More ambitious measures are described in recent reports by the Royal Society (Royal Society & Royal Academy of Engineering, 2018) and the Committee on Climate Change (2018). The pathway simulated using the FABLE Calculator is largely based on assumptions from the Committee on Climate Change report. These include measures such as improving agricultural productivity, shifting of diets towards healthier eating guidelines, food waste reduction, and afforestation. Projected outcomes from simulating this pathway using the FABLE Calculator show that net zero emissions are still not reached by 2050 but are reduced from 42 to 13 Mt CO2e/year. This is largely due to major shifts away from livestock-based foods, leading to reductions in pastureland, as well as an increasing area of new forests.

The Committee on Climate Change report focuses on measures that release land from current uses to provide for settlement growth and to maintain current per capita food production (with an increasing population) combined with measures to reduce greenhouse gas emissions from land. Some measures included in the report cannot currently be represented explicitly within the FABLE Calculator. These include moving horticulture indoors, low-carbon farming practices, forestry management, agro-forestry and hedgerows, bioenergy crops, sequestration of soil carbon (e.g. with biochar and/or mineral carbon) and peatland restoration. Low carbon farming practices, such as nitrogen use efficiency, livestock measures (e.g. improving the feed digestibility of cattle and sheep, improving animal health and fertility, and improving the feed conversion ratio through the use of genetics) and manure management, can be partly included through assumptions related to productivity in the calculator. Including peatland restoration and management in the FABLE Calculator would be highly desirable in future Scenathons as it represents a key component of UK ambitions for reducing emissions, covering 12% of the land area with three quarters of peatlands being in various states of degradation.

It would also be useful to include bioenergy crops within future versions of the FABLE Calculator, as although current planting of such crops is very low, there is an ambition to increase this level to consider the emissions savings from displacing fossil fuels alongside any net carbon benefits that are derived while growing these crops (Committee on Climate Change, 2018). Furthermore, some food sectors are not included in the Calculator, in particular fish supply is not modelled, which has a bearing on the results due to the assumption of dietary shifts towards increased fish consumption. Freshwater aquaculture may compete for scarce water resources with irrigated agriculture.

Other cross-sectoral interactions that it would be useful to represent in the FABLE Calculator include better inclusion of biodiversity and habitat indicators (as the UK has a range of goals regarding biodiversity, but these are difficult to match to the current metric in the calculator); effects on water resources (i.e. is sufficient water available to irrigate crops in the future?) and water quality (as diffuse pollution from arable land and pastures are now the main source of freshwater pollution and dairying is projected to become more intensive and concentrated on lowland pastures in the pathway).

Technological innovation (alongside behavioral change) is seen as key to enabling the UK to meet its land use objectives. UK agricultural productivity growth has lagged behind other developed countries in the last decade and further investment in innovation and technology will be crucial for delivering a range of options that can: (i) increase agricultural productivity sustainably, including the use of breeding to boost crops yields; (ii) reduce on-farm non-CO_2 emissions through the development of low-carbon fertilizers, and the use of genetic selection of livestock for inherently low enteric emissions; and (iii) reduce production costs to deliver at scale a range of novel protein sources that are produced without the requirement for land (e.g. synthetic meat and dairy products) (Committee on Climate Change, 2018).

There is significant political interest in implementing sustainable land use pathways in the UK. Specifically, the UK's exit from the EU presents a mix of increased uncertainty and a potential unprecedented opportunity for land use change through the design and implementation of new environmental land management policies that support a move towards alternative land uses and reward land-owners for public goods that deliver climate mitigation and adaptation objectives where wider environmental benefits are also achieved (Committee on Climate Change, 2018). However, there are key barriers to transitioning to different patterns of land use and management, including inertia in moving away from the status quo; mismatched financial incentives and other non-financial barriers (e.g. 30-40% of UK farms are estimated to be tenanted with the average tenancy being only 3.7 years, although in terms of area many of these farms are small); and a lack of information and support for land managers and consumers.

In order to develop the integrated policies to address these challenges there needs to be buy-in across government departments and from national to local scales to the increased ambitions. In particular, there needs to be a process to gain public support and to reconcile differences between the preferences of individuals and communities with societal needs. Spatially-explicit modelling tools are needed to support such awareness raising and detailed planning at fine resolutions that are relevant to farmers, land owners/managers and local communities.

Units

% – percentage
bln – billion

cap – per capita

CO_2 – carbon dioxide

CO_2e – greenhouse gas expressed in carbon dioxide equivalent in terms of their global warming potentials

GHG – greenhouse gas

Gt – gigatons

ha – hectare

kcal – kilocalories

kg – kilogram

kha – thousand hectares

km^2 – square kilometer

kt – thousand tons

Mha – million hectares

mln – million

Mt – million tons

t – ton

TLU –Tropical Livestock Unit is a standard unit of measurement equivalent to 250 kg, the weight of a standard cow

t/ha – ton per hectare, measured as the production divided by the planted area by crop by year

t/TLU, kg/TLU, t/head, kg/head- ton per TLU, kilogram per TLU, ton per head, kilogram per head, measured as the production per year divided by the total herd number per animal type per year, including both productive and non-productive animals

tln – trillion

USD – United States Dollar

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