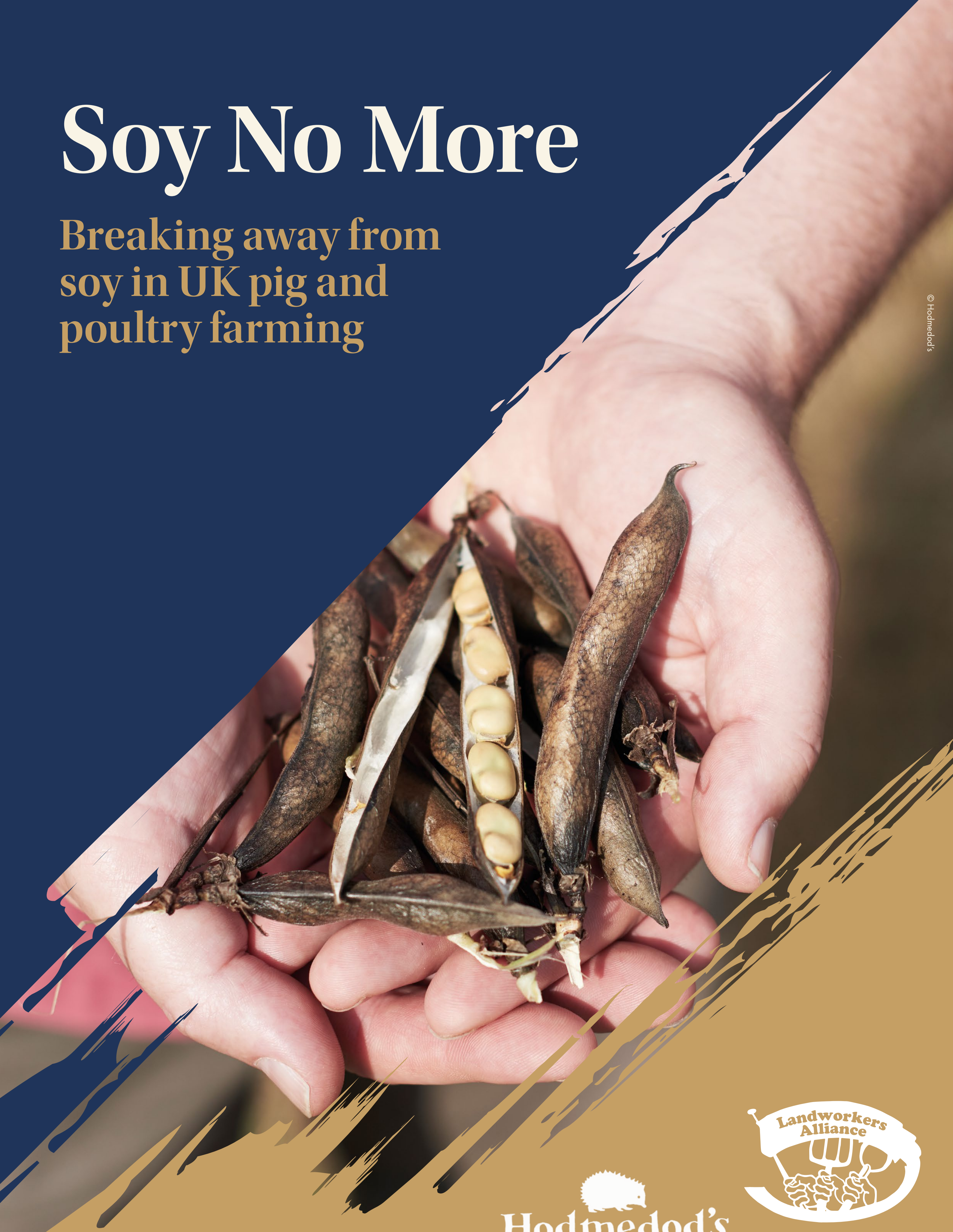
Soy No More

Breaking away from soy in UK pig and poultry farming



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A report by The Landworkers' Alliance, Pasture for Life, Sustain and Hodmedod (2023)

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Executive Summary

Industrial farming is a primary contributor to global warming, environmental damage and land-use change. While a lot of attention has been given to methane emissions from ruminants[1] the environmental impacts of the global animal feed supply chain have been obscured, in particular, the role of soy overproduction to feed the industrial pig and poultry sector.

In recent decades soy has become the primary protein source in livestock feed, and its overproduction has been the subject of scrutiny because of the role it plays in driving deforestation overseas in biodiverse regions such as the Amazon.

This report shows how soy supply chain certification initiatives[2] alone will never be effective in halting deforestation, and that there is an urgent need to reduce our soy demand if we are to take meaningful steps towards climate change mitigation and reversing biodiversity loss.

For the UK, reducing soy demand necessitates an exploration of replacement protein sources for pig and poultry feed, as nearly 90% of the UK's soy imports are used for animal feed – the majority of which is consumed by the industrial pig and poultry sector.

Furthermore, because of the precarity and exposure to price volatility of relying on global commodity markets for animal feed, this report argues that transitioning to soy-free alternatives could also support a more resilient and economically viable pig and poultry sector in the UK.

In order to explore the feasibility of replacing soy with alternative feeds, this report models several different scenarios:

- **The first scenario models replacing soy in UK pig and poultry feed with home-grown legumes.** If we were to keep production and consumption of pig and poultry feed the same as it currently is, our modelling demonstrates that UK total cropland for pig feed would need increasing by an estimated 60%, and for poultry feed by an estimated 78%. Within a context of increasing competition over land-use in the UK combined with the need to become more self-sufficient in food production this is not a realistic option.
- **The second scenario takes land-use into consideration,** and demonstrates that if we were to replace soy with home-grown legumes without increasing total UK cropland area, then we would need to eat 44% less poultry and 41% less pork. However, with such a reduction of protein in our diets as a result of eating less meat, this would not leave enough room to increase production of plant-based proteins such as pulses which would be needed to supplement the loss of protein.
- **The third scenario not only takes land-use into consideration, but also food-feed competition.** It explores what might be possible if current UK cropland area was prioritised for growing pulses for human consumption, and pig and poultry were fed on by-products and food waste inedible for humans; such as heat treated food waste, insect feed, pasture, and co-products from pulse production.

1 Although we recognise the importance of including ruminants in discussions around the sustainability of our livestock systems, the issues relating to ruminants are different to those relating to non-ruminants (such as pig and poultry) and the complexities warrant in-depth and nuanced analysis which is beyond the scope of this report.

2 Supply chain initiatives are efforts to mitigate and/or prevent negative impacts in supply chains through the "adoption of aspirational goals by single companies or coalitions of actors, corporate codes of conduct, and sustainability standards that, in some cases, are implemented through certification schemes and moratoria." Lambin, Eric F., et al. "The role of supply-chain initiatives in reducing deforestation." *Nature Climate Change* 8.2 (2018): 109-116.

To ensure people living in the UK have an adequate protein intake – from both plants and animal products, calculations for this third scenario estimate that pig and poultry production would have to decrease by over 80%. To put this into perspective, this report also highlights how **the majority of the UK's poultry production is embedded within large-scale, vertically integrated supply chains dominated by agribusiness corporations, and that pig production remains highly concentrated in large-scale operations.** We envision large-scale, vertically integrated, pig and poultry farms phased out with their farming operations diversified to produce legumes for human consumption.

Although a transition to Scenario 3 would require people to adjust their diets to include more pulses, and less pork and chicken, it would mean that small and medium-scale pig, poultry and legume farmers could actually make up a larger market share of the sector, and build resilient and thriving farming businesses which focus on the production of higher quality and more ethically produced meat.

Insect protein and food waste treated in specialist facilities are part of the solution only in as far as they use truly unavoidable food waste and biomass that cannot be eaten directly by people or farm animals. New legislation will be needed to ensure that insects and unavoidable food waste deliver a safe and sustainable contribution to the food system.

This report aims to highlight the fundamental links between soy production and deforestation, vertically integrated animal feed supply chains and industrial pig and poultry farming, and to offer a more resilient and ecologically sustainable alternative in which small-medium scale farmers can thrive.

In order to support this transition away from soy, and towards more resilient alternatives, the report concludes with the following set of policy recommendations:

1. Agree a government industry pathway away from soy which will involve government working with experts, industry and society, to set feed pathways with annual targets for reducing demand for soy, reducing demand for pork and poultry and phasing out the industrialised farm model
2. Full transparency in supply chains - ie new mandatory transparency rules for corporations giving fully open data on sourcing of soya and imported beef given the interrelationship
3. New domestic feed sources to replace soy - ie policies including research and development, financial support and private investment incentives to increase the sustainable supply of feed legume co-products, etc without increasing feed crop land
4. Strong, clear demand-side policies to reduce UK animal product consumption, through public procurement policy and others to deliver the reduction in demand for pork and poultry products using unsustainable feeds and increase plant protein consumption
5. Land use strategy and action to reduce animal impact - start developing a process that will include livestock and feeds and overseas land take, and which will set strong targets to reduce food-feed competition (currently over half of wheat & barley is fed to animals)
6. Farm support in the agricultural transition plan (ATP) to support soy-free systems - ensure farm support via financial support, productivity, facilitation, training and skills. This needs to also ensure innovation grants are delivered for the planned phase out of soy use of grains for feed.
7. Planning policy and guidance which will deliver the right guidance to planning authorities to remove unsustainable farm systems and support farmers in transition to new farming practices.
8. Research & Development of alternatives suitable for the SME pig and poultry sector. A major new research, development and innovation funds should support transition via farmer-led and institutional work on alternatives.

Figure 1. Summary of scenarios

Parameters	Scenario 1: Replace soy in UK pig and poultry feed with UK-grown pulses	Scenario 2: Replace soy in UK pig and poultry feed with UK-grown pulses *without increasing current UK cropland area*	Scenario 3: Replace soy in UK pig and poultry feed with *unavoidable food waste, without increasing current UK cropland area and ensuring adequate protein intake in human diets*
Land use change	60% more land needed for pig feed and 78% more land needed for poultry feed compared to current production levels.	No change in feed cropland and overall cropland area	Overall reduction of 6% of UK cropland & healthier rotations. Increase legume cropland by 190k ha. Decrease cereal cropland by 540k ha.
Pig and poultry imports	No change – UK still imports around 700,000 tonnes of pork[3] UK is roughly self-sufficient in poultry products	Pork imports halted (in the last 10 years the UK imported between 30 and 40% of the pork it consumed[4])	Pork imports halted UK is roughly self-sufficient in poultry products
Plant protein supply for food/ human diet protein levels	–	No additional cropland available for growing plant protein	Enough existing cropland turned over to legumes to ensure 75g of pulses per person per day[5]
Soy imports for food	7% of total business-as-usual soy imports continue to be used for food	7% of total business-as-usual soy imports continue to be used for food	12% of total business-as-uaul soy imports used as food, offset by halting all imports of pork (currently accounting for 6% of embedded soy imports)
Meat supply	No change	41% less pork 44% less poultry products	82% less pork (comprised of halting pork imports and a reduction of 73% of UK pork production) 86% less poultry products

Methodology, data and assumptions that led to these findings are set out in the supplementary spreadsheet[6]

3 UK Gov, 2023, Latest cattle, sheep and pig slaughter statistics: https://www.gov.uk/government/statistics/cattle-sheep-and-pig-slaughter

4 UK Gov, 2023, Meat Supplies: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1143289/meatsupplies-17mar23.ods

5 This also allows for a halving of ruminant animal products, while ensuring adequate protein intake and simultaneously further freeing up land for climate mitigation and other purposes.

6 https://landworkersalliance.org.uk/wp-content/uploads/2018/10/Soy-No-More-Calculations.xlsx

Introduction

There is overwhelming evidence that the current industrial agricultural system is a key driver of global warming, biodiversity loss and land-use change. Industrial livestock farming plays a large part in this, and while its impact is often assessed in terms of the methane emissions of ruminants, what is often overlooked is the land-use impact of growing crops for animal feed.

Of the 5 billion hectares of land used for agriculture globally, almost 80% is used for livestock, 1.65 billion hectares of which (a third of global cropland area) is used to grow feed.[7]

34% of the UK's protein intake comes from meat and meat products, but because of our limited land, the overseas land-use footprint of our meat supply is significant.

Because of its high protein content and digestible amino acids, in recent decades soy has become the primary protein source for animal feeds. Now, **approximately 76% of global soy production goes towards feeding livestock**[8], mostly for pigs and poultry.

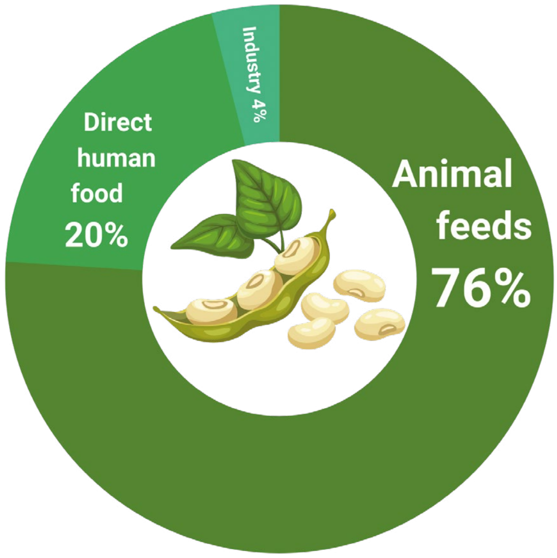


Figure 2. Global soy production

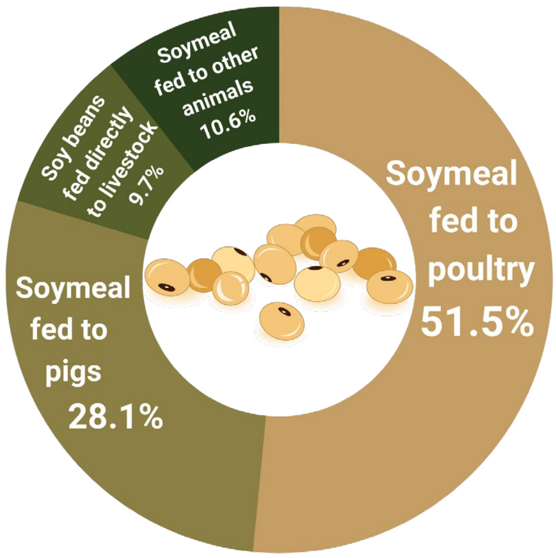


Figure 3. Of the soy that goes to animal feed

[7] Livestock and Landscapes (FAO): https://www.fao.org/3/ar591e/ar591e.pdf

[8] Most of the rest is used for biofuels, industry or vegetable oils. Just 7% of soy is used directly for human food products such as tofu, soy milk, edamame beans, and tempeh. Ritchie. H and Roser, M. (2021) - "Forests and Deforestation": 'https://ourworldindata.org/forests-and-deforestation.

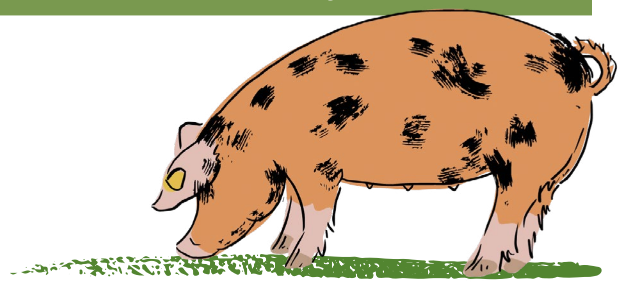
Pig and poultry are the largest direct consumers of soy in the UK too. The UK imports on average **3 million tonnes of soy for animal feed each year**, the majority of which is grown in South America; either in the Amazon or in other biodiverse regions which, as a result of increased soy production and other industries, such as timber extraction and cattle ranching, continue to be vulnerable to high rates of deforestation.

Our dependence on soy imports to support pig and poultry production is not only unsustainable in terms of land-use implications overseas, but it is also increasingly risky in terms of our food security and farming livelihoods here in the UK.

Brexit, the COVID-19 pandemic, the war in Ukraine and extreme weather events caused by global warming have all highlighted the risks of relying on global food supply chains to feed ourselves; the global animal feed supply chain is a perfect example of this.

Between 2016 - 2021 the price of soy on international markets fluctuated between £300/tonne and £380/tonne, and in 2022 rose as high as £500/tonne[9]. This price volatility creates a precarious situation for UK livestock farmers, who often face negative profit margins.[10]

The cost of pig production in the UK has risen over time – with prices for feed not only making up the vast majority of overall costs, but also being the primary reason for increased production costs.[11] In December 2016, feed costs in 14 EU pig producing countries made up between 50% and 67% of total pig production costs[12]. 2022 saw "all-time-highs'' in global soy and wheat prices[13], and combined with abattoir labour shortages, this resulted in record losses for pig farmers of as much as £50 per pig in the first half of the year[14]. Similarly, in a 2022 article an ADHB analyst highlighted that *"with soaring energy and feed costs for producers, margins are getting squeezed tighter for poultry and egg producers in the UK. For layers in particular, the rise in inputs is not being matched by a rise in purchase price, which is leading to some cutting production while others exit altogether".*[15]



[9] AHDB, 'UK Feed Ingredient Prices': https://ahdb.org.uk/cereals-oilseeds/feed-ingredient-prices

[10] AHDB, 'Pork Cost of Production and Net Margins': https://ahdb.org.uk/pork-cost-of-production-and-net-margins

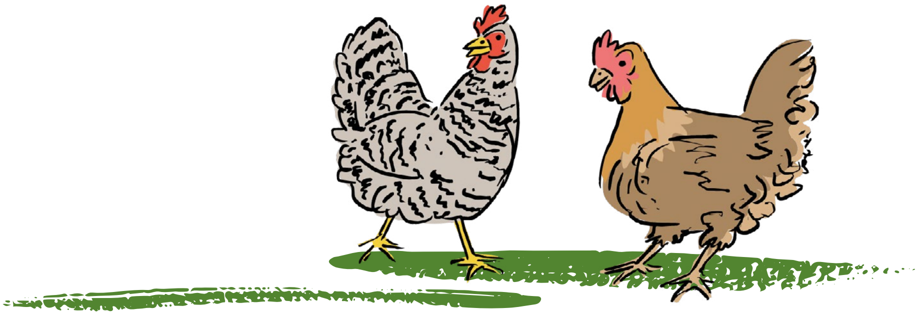
[11] ibid

[12] AHDB, 'EU Cost of Production - Estimates of the Current Cost of Pig Meat Production in Various Countries': http://pork.ahdb.org.uk/prices-stats/costings-herd-performance/eu-cost-of-production/.

[13] This is Money, 'Porkflation: Bacon and sausages are about to get even pricier as UK pig prices jump 27% and farmers face all-time-high feed costs' 1st August 2022: https://www.thisismoney.co.uk/money/markets/article-11069227/Porkflation-UK-pig-prices-jump-27-farmers-face-record-feed-costs.html

[14] AHDB, supra note 10

[15] AHDB, 'Analyst Insight: In a flap about poultry feed demand' 12th May 2022: https://ahdb.org.uk/news/analyst-insight-in-a-flap-about-poultry-feed-demand



Forecasts for commodity feed price increases and volatility are complex, not just because of the uncertainty driven by environmental factors but also because of the influence of commodity speculation.[16] But what is important for the context of this report is that **prices for conventional soy-based feeds are likely to increase based on volatile and ever more pressured global agricultural commodity markets.**

We therefore face a challenge both globally and in the UK: **how do we feed ourselves enough protein, but in a way which does not drive land-use change and deforestation overseas and which improves the livelihoods of farmers here in the UK.**

This report looks at how we can remove soy from pig and poultry feed supply chains here in the UK, and explore alternative types of locally produced feed that may present themselves not only as the more environmentally sustainable option, but also the more economically feasible and reliable alternative.

Land use footprint and protein efficiency

In 2020, 71% of the UK's land (17.3 million hectares), was used for agricultural production. Of that, nearly three quarters is grassland and only one quarter is used to grow crops[17]. In the last five years in the UK, 13 million tonnes of cereals (mostly wheat and barley) were fed to animals yearly, compared to 10.5 million tonnes for direct human consumption.[18] Monogastric animals (e.g. pigs and poultry) consume large volumes of human-edible food in a wasteful way: **for every 100g of protein – mostly from soy – fed to a broiler chicken, only 37g of protein ends up on our plates in the form of edible chicken meat.** In the case of pork, this figure is a mere 21%. Chicken and pork deliver only 27% and 16% respectively of the calories that they were fed.[19]

[16] Prakash, A. (2011) 'Safeguarding Food Security in Volatile Global Markets'. FAO: http://www.fao.org/docrep/013/i2107e/i2107e.pdf

[17] de Ruiter, H. et al. 'Total Global Agricultural Land Footprint Associated with UK Food Supply 1986–2011' Global Environmental Change 43 (March 1, 2017): 72–81, https://doi.org/10.1016/j.gloenvcha.2017.01.007.

[18] AHDB, 'End-Season 2021-22 UK Cereal Supply and Demand' 29th September 2022: https://projectblue.blob.core.windows.net/media/Default/Market%20Intelligence/cereals-oilseeds/supply-demand/uk-supply-demand/2021-22%20-%20Sep%20update.pdf

[19] Fry, J.P. et al., 'Feed Conversion Efficiency in Aquaculture: Do We Measure It Correctly?' *Environmental Research Letters* 13, no. 2, 1st February 2018

1

The Problem With Soy

Over the past 50 years, global production of soy has increased faster than any other crop from 27 million tonnes to 350 million tonnes[20] and the UN Food and Agriculture Organization predicts that it may reach 515 million tonnes by 2050[21]. Approximately 76% of this global soy production is used as animal feed[22], mainly for pigs and poultry.

The demand for soy oil for human consumption as a driver of demand

"One might view soybean meal or cake as only a by-product of the production of soy oil, as its economic value is much lower (a kilogram of soy oil is about twice the value of a kilogram of soy cake). However, since the crushing of soybeans produces much less oil (20% by weight) than cake (80%), only a third of the overall value of a kilogram of crushed soybeans is derived from the oil, as compared with two thirds from the cake. Soy oil is also one of the cheapest vegetable oils on the commodity market, whereas soy cake is the most valuable of all oilseed cakes due to its favourable amino acid profile and the low levels of anti-nutritive compounds it contains after heat treatment. ***It is therefore likely that the growth in soy production has primarily been driven by the demand of soy cake for feed, and hence by the growing demand for animal-based products.*** *However, because the oil and the cake originate from the same bean, there is a mutual and economically convenient dependency between their uses. The rapid expansion of soy and its use for feed is therefore likely to have been facilitated by concurrent increases in the demand for vegetable oil."*[23] This also means that reducing the demand for soy cake for animal feed can have knock-on implications in terms of global supply of vegetable oils (see Appendix 6 of this report).

[20] Ritchie, H. and Roser, M (2021) 'Soy', *Our World in Data*: https://ourworldindata.org/soy.

[21] WWF (2017) 'Appetite for Destruction'

[22] Most of the rest is used for biofuels, industry or vegetable oils. Just 7% of soy is used directly for human food products such as tofu, soy milk, edamame beans, and tempeh (*Ritchie. H and Roser, M. (2021) - "Forests and Deforestation": 'https://ourworldindata.org/forests-and-deforestation.)*

[23] Fraanje, W and Garnett, T. (2020) 'Soy: Food, Feed, and Land Use Change', Foodsource: Building Blocks). Food Climate Research Network, University of Oxford

1.1 Environmental impact of industrial soy production

The land-use footprint of soy production globally is estimated at 131 Mha[24] – about one third the size of the EU[25]. Over half of the world's soy comes from South America, with Brazil alone accounting for a third of global production[26]. This means that a significant proportion of the world´s soy comes from high biodiversity regions such as the Amazon, the Cerrado and the Gran Chaco regions, which continue to be particularly vulnerable to high rates of deforestation[27].

From 2000 to 2019, the area under soybean cultivation in South America more than doubled from 26.4 Mha to 55.1 Mha, with the most rapid expansion occurring in the Brazilian Amazon.

While there have been some per hectare yield improvements as a result of increased chemical inputs and new GM (genetically modified) varieties, increasing soy production relies primarily on increasing land use[28]. From 2000 to 2019, the area under soybean cultivation in South America more than doubled from 26.4 Mha to 55.1 Mha, with the most rapid expansion occurring in the Brazilian Amazon, where the soybean area increased more than tenfold, from 0.4 Mha to 4.6 Mha[29].

Soybean-driven deforestation is concentrated at active frontiers,[30] nearly half of which are located in the Brazilian Cerrado – the largest savanna in Brazil and one of the most biodiverse in the world – and in Brazil's centre-west and northeastern states[31]. In northwest Argentina, soybean plantations have been encroaching into the biodiverse Chaco region from both the western and eastern sides. In eastern Paraguay, the area of land under soybean cultivation continues to grow, threatening to replace the areas of ancient Atlantic forests that remain, whereas in the western Paraguayan Chaco, soybean fields have just started to emerge. In central Bolivia, soybean cultivations are rapidly replacing the tropical Chiquitania forest.

24 FAOSTAT (2022) 'Food and Agriculture Data'

25 WWF, RSPB, (2022) 'Riskier Business: The UK's Overseas Land Footprint'

26 Rose, H. and Ritchie, M (2021) supra note 20

27 TRASE (2018) 'Assessing Deforestation Risk in Brazilian Soy Exports', *Trase Yearbook* (blog), 7th June 2018: https://yearbook2018.trase.earth/chapter5

28 Rose, H. and Ritchie, M (2021) supra note 20

29 Song, X et al. (2021) 'Massive Soybean Expansion in South America since 2000 and Implications for Conservation', *Nature Sustainability* 4, no. 9, 784–92

30 'Active frontiers' are recently deforested areas adjacent to large areas of primary forest - as opposed to deforestation of secondary growth or isolated patches

31 Schneider, M. et al (2021) 'Soy Production's Impact on Forests in South America' Global Forest Watch: https://www.globalforestwatch.org/blog/commodities/soy-production-forests-south-america/

Defending Indigenous land rights is defending the forest

Protecting Indigenous land rights is critical for conserving the earth's primary forest habitats and their rich biodiversity. Indigenous people guard over 80% of the planet's biodiversity despite making up just 5% of the global population. Not only has large-scale soy production in South America encroached on Indigenous lands resulting in deforestation and displacement of Indigenous communities but the industrial farming methods and use of chemical inputs on soy plantations has polluted the surrounding soils and rivers, posing enormous health risks to local Indigenous communities.[32]

Indigenous people protect 80% of the earth's biodiversity despite making up just 5% of the global population.

In 2018 Brazil was found to be the world's biggest consumer of pesticides classed as seriously hazardous to health or the environment. These hazards included acute toxicity to humans, chronic exposure risks like cancer or reproductive failure, high persistence in the environment, and high toxicity to bees. **Almost two-thirds of this Brazilian highly hazardous pesticide spending went on the country's soy plantations.[33]**

[32] Landworkers' Alliance (2023) 'A plea from Kayapo people of Brazil' (film) *Forthcoming*

[33] Unearthed 'Soya, corn and cotton make Brazil world leader for hazardous pesticides', 20th February 2020: https://unearthed.greenpeace.org/2020/02/20/brazil-pesticides-soya-corn-cotton-hazardous-croplife/

1.2 Improving sourcing vs. reducing demand

Because of increased public awareness and pressure regarding the impact of soy production, there have been various attempts by the private sector to control supply chains and source only "deforestation-free" soy.

However, soy traders in the Brazilian market with zero-deforestation commitments – Cargill, Bunge, ADM and Amaggi – have been shown to be as much at risk of trading deforestation-linked commodities from both the Amazon and Cerrado, as companies that have not made such commitments[34]. For example, in 2018, five traders and multiple soy farmers were fined US$29 million by the Brazilian government for soybean cultivation and purchasing connected with illegal deforestation[35]. Two of these companies had zero deforestation commitments.

When there is rising demand for a crop that can only be grown on a limited supply of suitable land (in this case land in South America which can be farmed without direct or indirect environmental impacts), it is near-impossible for supply chain approaches alone to have a significant impact. This is particularly the case because zero-deforestation commitments are limited in scope – either geographically, such as the Soy Moratorium in the Amazon, or politically, by allowing "legal" deforestation. Such limitations in scope result in the displacement of deforestation to less scrutinised areas while hiding the role of soy expansion as an indirect, but no less powerful driver of deforestation and environmental destruction.

Legal deforestation

A 2022 investigation by Unearthed[36] into soy-driven deforestation in the Brazilian Cerrado confirmed that "legal deforestation is widespread, ingrained and endemic in our supply chains". The investigation unequivocally proved that Cargill, the UK's largest importer of soy and a major player in the UK chicken industry directly imported deforestation-linked soy, and supplied it to Tesco, Asda, Lidl, Nando's and McDonalds. However, since this deforestation took place in the Cerrado biome, which is not protected under Brazilian legislation, it is considered legal.

As the UK government's consultation on Due Diligence on Forest Risk Commodities acknowledged, half of all commodity-driven deforestation is legal in the country of production. Therefore, the local legality approach of the UK's due diligence on forest risk commodities in the 2021 Environment Act is inadequate for countries and regimes where standards are weak or being weakened and deregulation is becoming the norm. Moreover, by focusing on local legality, such legislation risks incentivising sourcing from places with weaker local regulation to ensure continued UK market access.

Interventions such as the Amazon Soy Moratorium with a limited geographic scope in a context of rising demand restricts the production of commodities in one place, therefore encouraging displacement of production to other locations. Compliance with country-specific supply-chain initiatives may also cause displacement across political boundaries. Under the Soy Moratorium, on-property leakage may occur when soy farmers continue to deforest for non-soy land uses such as cattle ranching[37].

[34] TRASE (2018) 'Trase Yearbook 2018: Sustainability in Forest-Risk Supply Chains: Spotlight on Brazilian Soy'

[35] Byrne, J. 'Traders, Farmers Fined over Links to Deforestation in Cerrado', *Feednavigator.Com*, 24th May 2018: https://www.feednavigator.com/Article/2018/05/24/Traders-farmers-fined-over-links-to-deforestation-in-Cerrado.

[36] Unearthed, 'Agribusiness Giant Cargill Again Linked to Amazon Deforestation', 14th January 2022: https://unearthed.greenpeace.org/2022/01/14/agribusiness-giant-cargill-amazon-deforestation

[37] Lambin, E.F. et al. (2018) 'The Role of Supply-Chain Initiatives in Reducing Deforestation', *Nature Climate Change* 8 (2), 109–16

Evidence of the link between soybean and cattle ranching in the form of pasture to cropland conversion is well documented by statistics and remote sensing data[38]. Linkages between soybean and cattle production are intensifying and many of the larger agribusiness companies in Brazil and Argentina are commonly active in both soybeans and cattle[39]. In general, while cattle ranching is the major direct driver of deforestation in the Amazon, soybean production still drives indirect deforestation, even with the Amazon Soy Moratorium area.[40]

In other words, since pasture expansion is the leading direct driver of deforestation in South America, achieving a deforestation-free soybean commodity chain requires consideration of how expanding its production area may indirectly drive deforestation by increasing land demand for pasture or other land uses elsewhere[41]. Ten percent of deforested lands were converted to soybean between 2000 and 2019, but although this proportion is relatively small, these lands are highly concentrated in the active deforestation frontiers.[42]

Large-scale soy and cattle producers in the Chaco region of Argentina, Paraguay and Bolivia tend to acquire land for deforestation in areas with laxer regulations, meaning that the tightening of regulations locally displaced deforestation to neighbouring areas[43]. Soy is the major driver of deforestation *in the Chaco and Cerrado* biomes[44] and global growth of the industry is driving a conflict between soybean production, communities and conservation in Africa's savannas and dry forests which contain astonishing biodiversity[45]. Supply chain analysis shows that although soy-associated deforestation declined in the Amazon after the introduction of the Soy Moratorium, there was no change in the exposure of companies or countries adopting zero deforestation commitments to soy-associated deforestation in the Cerrado.[46]

In other words, achieving changes in land use within supply chains or regions is not sufficient to reduce global deforestation[47]. Leakage and displacement, low and selective adoption, and unintended social consequences all undermine the

[38] Arima, E.Y. et al. (2011) 'Statistical Confirmation of Indirect Land Use Change in the Brazilian Amazon', *Environmental Research Letters*, 6 (2)

[39] Gasparri, N.I. et al (2016) 'The emerging soybean production frontier in Southern Africa: conservation challenges and the role of south-south telecouplings' *Conservation Letters*, 9(1), pp.21-31.

[40] Gollnow, F. et al (2018) 'Property-level direct and indirect deforestation for soybean production in the Amazon region of Mato Grosso, Brazil' *Land use policy*, 78, pp.377-385

[41] Song, X et al. (2021) supra note 29

[42] Ibid

[43] Lambin, E.F. et al. (2018) supra note 37

[44] Fehlenberg, V. et al. (2017) 'The Role of Soybean Production as an Underlying Driver of Deforestation in the South American Chaco', *Global Environmental Change* 45, pp. 24–34; Pendrill, F. and Persson, U.M (2017) 'Combining Global Land Cover Datasets to Quantify Agricultural Expansion into Forests in Latin America: Limitations and Challenges', *PloS One* 12(7)

[45] Gasparri, N.I. et al (2016) supra note 39; Action Aid Brazil and Rede Social de Justiça e Direitos Humanos(2017) 'Impactos Da Expanssão Do Agronegócio No Matopbia: *Comunidades e Meio Ambiente.*

[46] Erasmus K. H. J. zu Ermgassen et al. (2020) 'Using Supply Chain Data to Monitor Zero Deforestation Commitments: An Assessment of Progress in the Brazilian Soy Sector', *Environmental Research Letters* 15 (3)

[47] Lambin, E.F. et al. (2018) supra note 37

potential of private interventions to limit deforestation. **Unless demand is reduced** or met by other means, **displacement of deforestation to areas not covered by supply chain initiatives is likely to occur.**[48]

WWF estimate that only 2.8% of Brazilian soy is certified by the Round Table on Responsible Soy (RTRS) as sustainably produced, 2.1% in Argentina and 0.9% in Paraguay, suggesting considerable risks for UK imports from these countries of deforestation, land conversion and human rights abuses[49].[50]

The Soy Moratorium was implemented alongside Brazilian government policy aimed at reducing Amazon deforestation. The public and retailer pressure surrounding the Moratorium undoubtedly created a positive climate for such policy implementation. However, the Moratorium has not been able to prevent a renewed upward trend in recent years. New increases in deforestation have been catalysed by various environmental setbacks that started with controversial changes in the Brazilian Forest Code in 2012 and have been intensified by recent weakening of the Ministry of the Environment's deforestation enforcement actions, disregard of related climate change policies, and law bills that may regularise illegally grabbed public lands[51]. In other words, without strong governmental policy and legislation, the Moratorium alone is not enough.

Moreover, a highly influential study in the journal Science found that it was because of very high rates of deforestation just prior to the Moratorium, that it was easy for soya expansion to happen in these already deforested lands[52]. Improvements in livestock yields also freed up land for soy. However, "eventually, cleared land that is suitable for soy production—the most profitable use of cleared land—will become scarce again putting deforestation pressure on the 120,000 km2 of forests that could be profitably converted to soy in the Brazilian Amazon but outside of protected areas.[53] Unfortunately, a significant upward trend in Amazon deforestation in the last few years – with 2020 having the greatest deforestation rate

48 ibid

49 WWF, RSPB, (2022) supra note 25

50 For more information on certification schemes, and their minimal adoption, see the Oxford University Building Block report on Soy (2022): https://tabledebates.org/building-blocks/soy-food-feed-and-land-use-change

51 Celso H. L. Silva Junior et al., 'The Brazilian Amazon Deforestation Rate in 2020 Is the Greatest of the Decade', Nature Ecology & Evolution 5, no. 2 (February 2021): 144–45, https://doi.org/10.1038/s41559-020-01368-x

52 Nepstad, D. et al (2014) 'Slowing Amazon Deforestation through Public Policy and Interventions in Beef and Soy Supply Chains', Science 344 (6188)

53 ibid

[54] Celso, H. and Junior, S.L. et al. (2021) 'The Brazilian Amazon Deforestation Rate in 2020 Is the Greatest of the Decade', *Nature Ecology & Evolution* 5(2) 144–45

1.3 Overview of UK soy imports

In 2020, the UK imported approximately 2.7 million tonnes of soy and soybean equivalents[55] directly as beans, meals and oil[56]. Overall UK imports of soy rose from about 2 million tonnes in 2000 to around 3 million tonnes by 2007 and have remained at around that level since.[57]

In addition to direct soy imports (composed of soymeal (56%), soybeans (21%) and soy oil (5%)[58]), there is an estimated further 18% of soy embedded within imported meat products from animals reared partially on soy – chicken (7%), pork (6%), dairy (2%), beef (2%), eggs (1%) and other products:

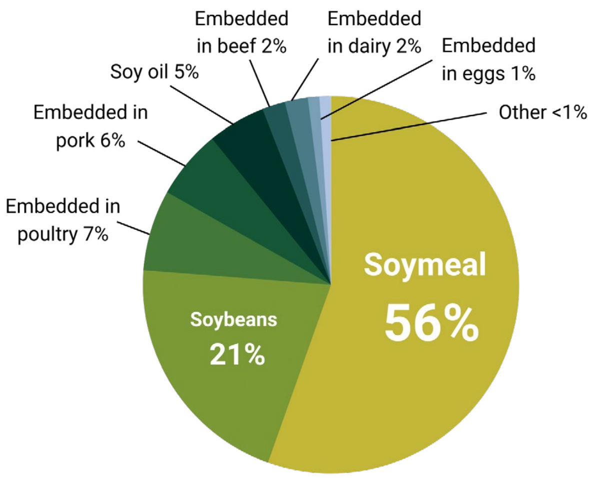


Figure 4. Estimated proportion of soy imported to the UK by product (average 2016-18) [59]

*chicken comprises around 88% of total imported poultry.

Of the 2.7 million tonnes of soybean meal equivalents imported directly to the UK in 2020[60], **an estimated 2.4 million tonnes (89%) is used for animal feed**[61]. The UK's total animal feed production in 2020/21 was composed of the following ingredients, with **soy cake and meal making up between 9 - 13%** over the past 20 years[62].

[55] Soybean meal equivalents reflects that when a soybean is crushed only a proportion of that weight is soya meal, most commonly used in animal feed (approximately 72.5% of the whole bean). The UK roundtable on sustainable soya also reports using a soybean equivalent figure, which is the volume of whole soybeans required to produce the meal and oil used in the UK and this figure is significantly higher: https://www.efeca.com/wp-content/uploads/2021/12/UK-RTSS-APR-2021.pdf.

[56] Efeca (2021) 'UK Roundtable on Sustainable Soya: Annual Progress Report 2021'

[57] HMRC (2022) 'Overseas Trade Data Table - UK Trade Info': https://www.uktradeinfo.com/trade-data/ots-custom-table/.

[58] WWF and RSPB (2020) supra note 25

[59] ibid

[60] Efeca (2021) supra note 56

[61] ibid

[62] AHDB (2023) 'GB animal feed production': https://ahdb.org.uk/cereals-oilseeds/cereal-use-in-gb-animal-feed-production

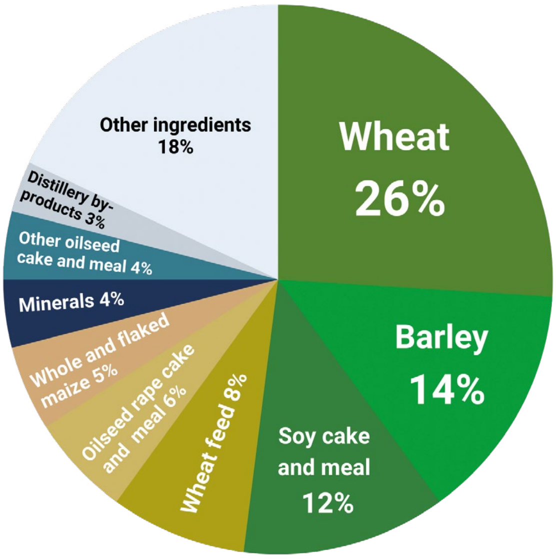


Figure 5. Composition of UK's total animal feed production

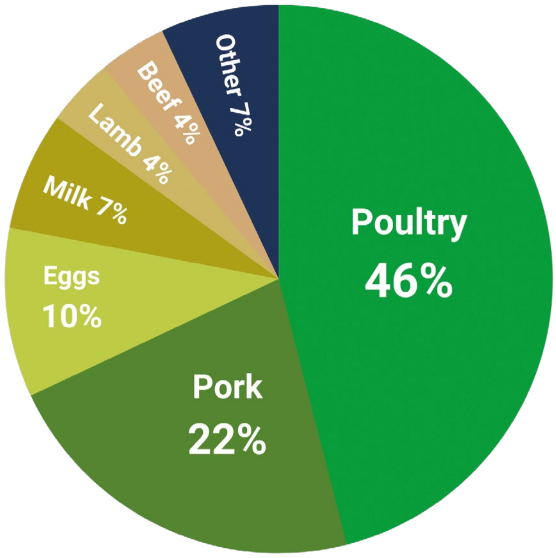


Figure 6: Pie chart representing 1.37 Million tonnes of soy cake embedded in the foods sold by 7 UK supermarkets[66]

A more detailed breakdown to the quantity of soybean meal in different types of feed can be found in Appendices 1 and 2.

The poultry sector is the largest user of soy in the UK, followed by pork.[63] Data showing the exact quantities of soy use by livestock type for the UK are not available, however a report by 3Keel analysed the embedded use of soy cake in the supply chains of seven UK supermarkets (see pie chart).[64] This breakdown includes both imported and domestic products and as supermarkets make up over 95% of the grocery market share in the UK[65] we can assume that these figures reflect the use of soy in UK livestock production, where poultry is the largest user, followed by pork, then cattle, then lamb, farmed salmon and seafood.

Origin countries

In the case of the UK, over three quarters of soy come from South America[67]. WWF estimate that the land required to grow soy overseas to satisfy the UK's average annual demand between 2016-18 was 1.7 Mha, an area nearly the size of Wales[68]. Moreover, GHG emissions from land-use change to produce soy imported into the UK were 18.8 MtCO2eq per year between 2016 and 2018, equal to about 35% of the emissions produced by

[63] WWF and RSPB (2020) supra note 25

[64] 3Keel (2018) 'Moving to deforestation free animal feed - 2018 Retail Soy Initiative.'

[65] Kantar, 'Grocery market share of Great Britain': https://www.kantarworldpanel.com/grocery-market-share/great-britain

[66] 3Keel (2018) supra note 64

[67] Efeca (2021) supra note 56

[68] WWF and RSPB (2020) supra note 25

the whole UK construction industry in 2016[69]. The country of origin for UK soy imports in 2020 is shown below, with **78% coming from countries in South America**.

Based on UK customs data for 2021, the UK's indirect imports of soy (whole bean, oilcake and other solid residues, flour and oil) are primarily via the Netherlands (17%), Ireland (3%) and Germany (1%)[70].

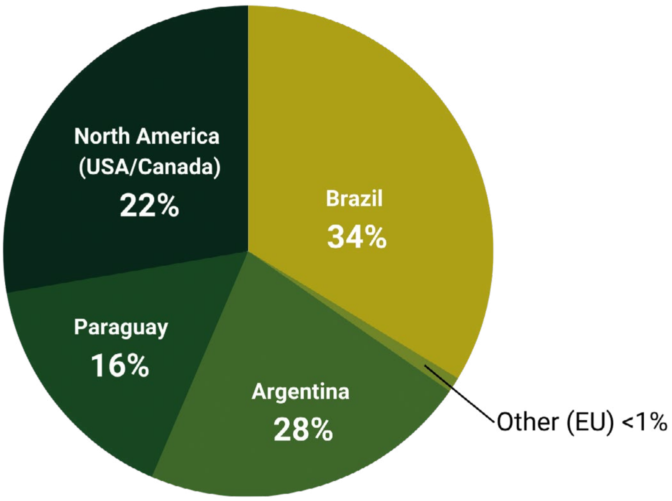


Figure 7: Origin countries of total UK soy imports*[71]

Where soy imported to the UK from the Netherlands and Ireland has been reallocated to their sourcing countries where the volumes were deemed significant (over 50,000 tonnes)[72]. This data includes soy for human consumption, but is mostly for animal feed[73].

The companies behind UK soy imports

From Brazil

In 2018, the UK imported 465,341 tonnes of soybean equivalent directly from Brazil, 72% of which were imported by Cargill (334,308 tonnes), 8% by Glencore (36,945 tonnes), 3% by Agrograin (15,000 tonnes) and 2% by Bunge (10,000 tonnes) – figures given here in soybean equivalent tonnes[74]:

According to TRASE, these imports from Brazil were in total responsible for 114,522 hectares of land use.[75 76]

Glencore and Agrograin are responsible for a disproportionate percentage of environmental impacts despite their lower import volumes, though Cargill still has the biggest environmental impact due to its higher import volumes:[77]

69 ibid

70 HMRC (2022) 'Overseas Trade Data Table - UK Trade Info', UK Trade Info: https://www.uktradeinfo.com/trade-data/ots-custom-table/.

71 UN Comtrade data cited in Efeca (2021) supra note 56

72 Efeca (2021) supra note 56

73 ibid

74 TRASE (2022) 'TRASE - Data Download': https://supplychains.trase.earth

75 ibid

76 TRASE also produces a deforestation risk exposure metric (http://resources.trase.earth/documents/data_methods/Trase_deforestation_risk_method_final%20Sept%202020.pdf) but this only covers areas of soya planted within 5 years of the deforestation event occurring . For example, this would mean that any area deforested between 2019 and 2022 (Bolsonaro government) and subsequently used for soya growing after 2024-2027 will not be associated with deforestation risk according to Trase's definition. As explained earlier in this report, we find it more useful to look at the research identifying the movement of the deforestation frontier in different areas and how this deforestation frontier overlaps with the major soy production areas, as well as general land use / pressure associated with soy production.

77 TRASE

Company	Proportion of import volume	Percentage of annual *direct* deforestation and habitat clearance risk (hectares)	Percentage of annual CO2 emissions from deforestation of land farmed with soy within five years of deforestation occurring.
Cargill	72%	57%	65%
Glencore	8%	27%	23%
Agrograin	3%	14%	9%
Other	17%	2%	2%

Figure 8. Deforestation and CO2 emissions associated with soy production in Brazil.[78]

From Argentina

In 2018, the UK imported 749,250 tonnes of soy equivalent directly from Argentina, 29% of which were exported from Argentina by Cargill (217,308 tonnes), 23% by Vicentin (169,636 tonnes), 16% by Aceitera General Deheza SA. (119,460 tonnes) and 13% by Glencore (98,543 tonnes)[79].

According to TRASE, these imports from Argentina were in total responsible for 288,112 hectares of land use[80]. The share of environmental impact between companies is similar to their volumes of soy exported, so these have not been shown separately as for Brazil above.

From Paraguay

In 2018, the UK imported 279,262 tonnes of soya equivalent directly from Paraguay, 29% of which were exported from Paraguay by Compania Paraguaya de Granos (208,957 tonnes), 23% by ADM (64,804 tonnes), and 2% by Bunge (5,500 tonnes)[81]

According to TRASE, these imports from Paraguay were in total responsible for 86,668 hectares of land use[82]. The share of environmental impact between companies very closely mirrors their volumes of soy exported, so these have not been shown separately as for Brazil above.

Cargill Company Profile

Cargill: As the third largest meat processor worldwide, Cargill has revenues of $115bn and is the third largest greenhouse gas emitter of all global livestock companies.[83] Cargill is America's largest privately held family-owned company, and with 14 billionaires in its ranks, Cargill has more billionaires than any other family[84].

The company has been accused of wide-scale deforestation to produce soy for industrial livestock feed, causing mass biodiversity loss.[85] Mighty Earth's Soy and Cattle Deforestation Tracker estimated that Cargill was linked to 66,189 acres of deforestation in the two years following March 2019, of which

78 Ibid

79 Ibid.

80 Ibid.

81 Ibid.

82 Ibid.

83 GRAIN and IATP (2018) 'Emissions Impossible: How Big Meat and Dairy Are Heating up the Planet'

84 Baer, D. 'The Secretive Cargill Family Has 14 Billionaires — More than Any Other Clan on Earth', *Business Insider* (blog), 2nd March 2015: https://www.businessinsider.com/cargill-family-has-14-billionaires-2015-3.

85 Mighty Earth, 'Cargill: The Worst Company In the World' (Washington DC, 2019).

13,850 acres was potential illegal clearance[86].

Cargill has been linked to deforestation and land grabbing from Indigenous territories in the Amazon region, through financing land-clearing operations for soy to feed hogs, chickens, and cows. In 2022, Cargill was named by Planet Tracker as one of the "Deforestation Dozen": 12 soy traders who control 89% of soy exports from the Paraguayan and Argentinian Gran Chaco rainforest, which has suffered a devastating 20% loss of native vegetation in 15 years[87].

Cargill operates Britain's only soybean crushing mill[88] in Seaforth, Liverpool, which has been operating since 1986. The plant produces high protein soybean meal, soy hulls, crude soy oil and crude tocopherol (vitamin E)[89]. The company has one other soybean crushing plant in Western Europe, in Barcelona, and numerous more all over the world.

Cargill's joint venture with UK poultry giant Faccenda – Avara Foods – processes 4.5 million of the 20 million chickens that are processed in the UK each week and was awarded the contract to be Tesco's primary fresh chicken supplier in 2019[90]. Avara Foods also owns the UK's biggest feed mill, near Hereford.

Cargill is also a major player in the aquaculture sector. In 2015 it acquired Norwegian aquafeed producer EWOS and has since become one of the largest global suppliers of aquafeed.[91]

Cargill's joint venture with UK poultry giant Faccenda, 'Avara Foods', processes 4.5 million of the 20 million chickens that are processed in the UK each week.

[86] Mighty Earth, 'Soy and Cattle Deforestation Tracker', *Mighty Earth blog* (2021): https://www.mightyearth.org/soy-and-cattle-tracker

[87] Mitchell, E. et al. (2022) 'Gran Chaco: The Deforestation Dozen' *Planet Tracker*

[88] See: Holmes, H. 'Tesco's New Soy Policy Must Go Further to Tackle Deforestation, Say Campaigners' *The Grocer*, 6th August 2021: https://www.thegrocer.co.uk/tesco/tescos-new-soy-policy-must-go-further-to-tackle-deforestation-say-campaigners/658711.article

[89] 'Liverpool | Cargill United Kingdom', accessed 15th May 2022: https://www.cargill.co.uk/en/liverpool-location.

[90] Ryan, C. 'Exclusive Interview: Avara Foods Opens Up', *Poultry News*, 11 April 2019: https://www.poultrynews.co.uk/business-politics/business/exclusive-interview-avara-foods-opens-up.html

[91] 'Bathgate | Cargill United Kingdom' accessed 15th May 2022: https://www.cargill.co.uk/en/bathgate-location

1.4 Vertical integration in the UK poultry sector

Because of its large entry costs and low margins, the UK poultry sector is dominated by vertically integrated supply chains. The main companies operating in the UK poultry sector are Moy Park, 2 Sisters Food Group, Cargill, Faccenda, Bernard Matthews and CCL Holdings (Crown Chicken Ltd).

A vertically integrated supply chain means farmers rear chickens on contract for major poultry meat companies who also run the slaughter and processing factories and sell the meat products to retailers and restaurants. Farmers can either have a vertically integrated contract or an independent contract with the companies:

- **A vertically integrated contract** means that a company sources the feed and chicks for the farmer who is paid (on a square metre per week basis) to cover costs for heating, labour and other costs. The farmer receives a good or average return depending on performance.
- **An independent contract** means the farmer is paid the market rate for the final product on a live weight basis and receives little return[92].

In the UK, 95% of broiler chickens are also raised in intensive poultry units (IPUs) which can house upwards of 40,000 birds in each unit.[93] The industrial scale of these units means that chickens are often housed in cramped conditions which impacts significantly on their quality of life and require the use of antibiotics to avoid the spread of diseases.[94]

Despite helping poultry producers to set up their businesses without the need for upfront costs for infrastructure, vertical integration means that farmers ultimately lose the decision making power over their own production systems. Instead these systems are designed by corporations whose interests lie primarily in generating shareholder profit.

While pig farming in the UK isn't as vertically integrated as the poultry industry, the majority of production is concentrated on large industrial-scale pig holdings. There are over 10,000 farms in the UK that keep pigs,[95] but according to the Campaign to Protect Rural England (CPRE), approximately 92% of the UK's pigs are kept on just 1,400 larger holdings[96] with just 10 corporate companies accounting for 35% of the UK's breeding sows.[97]

Out of the 10,000 farms in the UK that keep pigs, just 1,400 larger holdings keep 92% of the UK's pigs, with just 10 corporate companies accounting for 35% of the UK's breeding sows.

[92] Food and Drink Wales, 'Poultry Sub Sector: Analysis', GOV.WALES, 5 April 2016: https://gov.wales/poultry-sub-sector-analysis.

[93] Eating Better (2020) 'We Need to Talk About Chicken'

[94] ibid

[95] AHDB, 'UK Pig Numbers and Holdings': https://ahdb.org.uk/pork/uk-pig-numbers-and-holdings

[96] CPRE (2019) The Future of Pig and Poultry Farming: https://www.cpre.org.uk/wp-content/uploads/2019/11/The_future_of_pig_and_poultry_farming.pdf

[97] Pig Progress, 'United Kingdom: A pig industry on the edge' 8th December 2017: https://www.pigprogress.net/world-of-pigs/united-kingdom-a-pig-industry-on-the-edge/

2

Breaking Away from Soy and the Need to Increase UK Legume Production

Whether we are talking about replacing soy with home-grown feeds, or increasing human consumption of plant-based proteins, the implication is that we need to grow more protein crops in the UK such as legumes (e.g. alfalfa and clover), pulses (e.g. fava beans and peas) and amino-acid rich grains (e.g. quinoa).

What's the difference between a pulse and a legume?

Legumes are plants that belong to the Fabaceae family, they are often used in farming systems as cover crops to protect the soil, improve fertility or as feed for livestock. When used to describe feed, legume means the whole plant.

Pulses are the dry edible seeds of leguminous plants that end up on our plates or may end up in animal feed. Harvested when dry rather than green, pulses include chickpeas, beans, peas and lentils. Though soy is a legume and harvested dry it's classed as an oilseed rather than a pulse because of its fat content.

2.1 Replacing soy in pig and poultry feed

Livestock Type	Typical soy content UK feed	Explanation
Chickens (meat)	15-26%[98]	This varies according to production system, with "organic and free-range birds often having a bigger soymeal requirement due to their longer lifespan compared with more intensive production systems"[99].
Chickens (eggs)	10-21%[100]	This varies according to the production system.
Pigs	5-18%[101]	This varies widely, even within the same company, "due to indoor and outdoor rearing, variety and the lifespan of the pig"[102]. The level of soy in a pig's diet will vary depending on whether it is breeding, growing or finishing[103].

Figure 9. Typical soy content of UK pig and poultry feed

Replacing soy in pig feed

When the UK and the EU stopped the feeding of animal protein to omnivorous monogastric animals because of the Foot and Mouth and Bovine Spongiform Encephalopathy (BSE) outbreaks, the industry turned to soy as the most complete and digestible source of amino acids in increasingly precise diet formulations for increasingly fast-growing animals.

The reluctance of the pig industry to include home-grown pulses in pig diets is mainly due to a long-standing perceived association between high inclusions of peas or fava beans in pig diets with poor growth performance[104]. Moreover, industry view peas, beans and rape seed to be less palatable to pigs than soy.[105]

Even so, according to the UK pig industry, the proportion of soy used in pig feed has reduced from 20% to around 10% over the last 10 years[106] thanks to increased use of rapeseed and sunflower oil and coproducts such as distillers' grains.[107] Soy's high protein content of more than 40%, as well as the year-round predictable supply make the industry reluctant to substitute soy completely.

However, research trials have demonstrated that if diets are nutritionally balanced through synthetic amino

[98] 3Keel (2019) 'Moving to Deforestation Free Animal Feed: 2018 Retail Soy Initiative' 30: https://www.3keel.com/wp-content/uploads/2019/10/3keel_soy_report_2019.pdf

[99] ibid

[100] ibid

[101] ibid

[102] ibid

[103] NPA (2020) 'NPA Briefing Note on Soya Use in the Pig Industry': http://www.npa-uk.org.uk/hres/Soya%20briefing%20Feb%2020

[104] Houdijk, J (2012) 'Final Report: The Environmental Consequences of Using Home-Grown Legumes as a Protein Source in Pig Diets (Green Pig): https://www.pgro.org/downloads/FinalreportLINKProjectLK0682GreenPig.pdf

[105] 'Legumes Translated', accessed 12th May 2022: https://www.legumestranslated.eu.

[106] NPA, 'NPA Highlights Commitment to Sustainable Soya after Government Rainforest Announcement', National Pig Association, 23rd November 2020: http://www.npa-uk.org.uk/NPA_highlights_commitment_to_sustainable_soya_after_Government_rainforest_announcement.html

[107] Distillers' grains traditionally are a by-product from brewing alcoholic drinks, but currently the bio-ethanol industry supplies significant amounts of DDGS (dried distillers' grains with solubles) to the animal feed industry. The environmental issues related to bio-ethanol production, which in the UK principally uses wheat, sugar beet and maize as feedstock, are beyond the scope of this report.

acid supplements, which is also done for different amino acids in soy diets, high inclusion pea or bean diets will not affect growth performance.[108] There is, however, a need to acknowledge the environmental impact of synthetic amino production on an industrial scale, and using them must sit firmly within the context of reducing overall pig and poultry production in the UK.

Higher levels of peas and fava beans may be possible without detrimental effects on growth performance as feed formulations are now based on net energy and standardised ileal digestible amino acid digestibility, rather than digestible energy and digestible amino acids levels.[109]

Feed producers may prefer to give beans and peas certain treatments and additives to increase digestibility and reduce anti-nutritional factors, but it is possible to design rations using straight peas and beans. Soybeans are thermally treated and mechanically crushed to extract oil, the products of crushing (flakes) are then chemically treated for further oil extraction.[110] The resulting soymeal also contains anti-nutritional factors like trypsin inhibitors so it needs to be processed before it can be used as feed.[111] .

On-farm feed use of fava beans is estimated to use 70% of total fava bean production in Germany, 25% in France and 15% in the UK and Spain[112]. When it comes to peas, France and Germany consume more than twice as much as the UK, and Spain nearly three times as much, with feed being the main market.[113] Finally, various studies demonstrate the environmental and cost benefits of relying on synthetic amino-acid supplementation in pig diets, not only because reliance on soy can be reduced but also because the related reduction in crude protein reduces negative impacts of pig manure due to lower nitrogen levels.

108 Stein et al. (2004, 2006) cited in supra note 104

109 Stein et al (2004, 2006) supra note 107

110 SCOPA, Our Industry, accessed 15th May 2022: http://www.scopa.org.uk/our-industry.

111 Revoredo-Giha C. and Costa-Font, M. 'How to Delink the UK's Soybean Imports and Livestock Supply Chains from Deforestation in the Amazon' *LSE Business Review* (blog), 26th August 2021: https://blogs.lse.ac.uk/businessreview/2021/08/26/how-to-delink-the-uks-soybean-imports-and-livestock-supply-chains-from-deforestation-in-the-amazon

112 Legume Innovation Network, 'The EU Market for Faba beans' 21st September 2021: https://www.legvalue.eu/publications/the-eu-market-for-faba-beans/

113 Legume Innovation Network, 'The EU Market for peas' 21st September 2021: https://www.legvalue.eu/publications/the-eu-market-for-peas

The Green Pig Trials[114]

With match funding from DEFRA, a group of universities and key industry players carried out an extensive research project called Green Pig from 2008 to 2013. Green Pig replaced soybean meal with both peas and fava beans up to 30% inclusion in nutritionally balanced diets first in small trials with no effect on growth performance or carcass quality[115]. To test the applicability of these findings to commercial pig farming, trials with over a thousand pigs were conducted at three different conventional pig farms and showed no detrimental effect from high inclusion of home-grown pulses on performance or slaughter measures of pigs under commercial conditions. Furthermore, the first two of the large-scale trials showed high inclusion of peas and fava beans is possible in commercial grower and finisher pig diets even in the complete absence of soybean meal in the diet. In one of the trials, the return per animal was calculated based on the slaughter contract specification giving £125.23/pig, £125.19/pig and £125.89/pig for control soybean meal, pea and fava bean diets respectively showing that there was little effect of diet on the return from the slaughterhouse. The project also found that slurry from animals fed home-grown legumes will not be any different from that arising from the use of soybean meal as the only plant protein source. However, some issues around palatability need further research, and some soy is still required in young pig (starter-grower) diets.

While the Green Pig project seemed pioneering at the time,, the inclusion of peas in pig diets was not unheard of. For example, the University of Newcastle's "Feeding organic pigs: a handbook of raw materials and recommendations for feeding practice"[116] published in 2002, showed that finishing pig diets contain more peas than soy and diets for other stages still contain substantial amounts of peas relative to soy. This reflects the fact that the reliance on soy as the sole protein source has increased over time and that peas did in fact used to play a bigger role in pig diets in the past.

Examples of simple home mixed diets for different stages of a pig's growth can be found in Appendix 3.

Established use of food industry co-products in animal feed

Co-products of flour milling (bran, wheatfeed), cereal and confectionery production (biscuit meal), brewers' grains, molasses, rapeseed meal, surplus bread products are all well-established animal feed ingredients and command prices linked to the raw feed materials they substitute. In other words, their inclusion in animal feed diets are an integral part of the business model of the production of the primary co-product. As such all co-products, including those used in animal feed, are associated with a share of the environmental footprint.

Replacing soy in poultry feed

Poultry feed accounts for 45% of the total amount of animal feed that is produced in GB. Around two thirds of poultry diets are made up of cereals, mostly wheat.[117] There is a wealth of research on the potential replacements of soy in poultry feed, important studies are summarised in the following table.

[114] Houdijk, J (2012) supra note 104

[115] White et al. (2012) cited in Houdijk, ibid.

[116] Sandra Edwards, 'Feeding Organic Pigs. A Handbook of Raw Materials and Recommendations for Feeding Practice' (University of Newcastle, 2002).

[117] Askew, M. 'Analyst Insight: In a Flap about Poultry Feed Demand?' AHDB, 17th May 2022: https://ahdb.org.uk/news/analyst-insight-in-a-flap-about-poultry-feed-demand

Figure 10. Overview of studies replacing soy in poultry feed

Author	Broiler / layer	Proportion replaced	Protein replacement	Main finding
Leiber 2017[118]	Broiler	Half	Different combinations of black soldier fly larvae (BSF) with lucerne or peas, or combinations of peas and lucerne without BSF	Compared with the control, feed intake, daily weight gain, carcass weights and feed efficiency were equivalent for all experimental diets, indicating that the alternative feeds tested could replace part of the soybean products in broiler diets while achieving equivalent feed efficiency and product quality.
Heuel 2021[119]	Layer	Complete	BSF meal and fat	BSF can completely replace soybean meal in high-performing layers, but because of nutritional differences between the larvae materials of different origin the quality of the larvae has to be closely monitored before being used.
Koivunen 2016[120]	Broiler	Complete	Pea (2 cultivars), fava bean (2 cultivars), blue narrow leaf lupin	Both types of pea were a good source of energy and amino acids and their amino acids were well digested except for cystine which was moderately digested in the Karita cultivar. Fava beans were a moderate source of energy and have a good digestibility of lysine, but digestibility of the other amino was found to be relatively low. Most amino acids, in particular lysine, were well digested in blue lupin, but it was a poor source of AME. The poor energy value of blue lupin was related to its poor apparent ileal digestibility of dry and organic matter.
Amerah 2015[121]	Broiler	Partial	Rapeseed meal, sunflower meal	High inclusion of sunflower meal (SFM) and rapeseed meal (RSM) negatively influenced broiler performance. Enzyme supplementation improved feed conversion ratio at all levels of RSM and SFM included in this study, but did not recover the reduction in weight gain caused by high inclusion of RSM and SFM.

[118] F. Leiber et al. (2017) 'Insect and Legume-Based Protein Sources to Replace Soybean Cake in an Organic Broiler Diet: Effects on Growth Performance and Physical Meat Quality' *Renewable Agriculture and Food Systems* 32(1) 21–27

[119] Heuel, M. et al (2021), 'Black Soldier Fly Larvae Meal and Fat Can Completely Replace Soybean Cake and Oil in Diets for Laying Hens' *Poultry Science* 100 (4)

[120] Koivunen, E. et al. (2016) 'Digestibility and Energy Value of Pea (Pisum Sativum L.), Faba Bean (Vicia Faba L.) and Blue Lupin (Narrow-Leaf) (Lupinus Angustifolius) Seeds in Broilers' *Animal Feed Science and Technology* 218, pp. 120–27

[121] Amerah, A.M. et al. (2015) 'Effect of Different Levels of Rapeseed Meal and Sunflower Meal and Enzyme Combination on the Performance, Digesta Viscosity and Carcass Traits of Broiler Chickens Fed Wheat-Based Diets," *Animal* 9(7) pp. 1131–37.

Tallentire 2018[122]	Broiler	Complete	Microalgae, macroalgae, duckweed, yeast protein concentrate, bacterial 14 protein meal, leaf protein concentrate and insects	Incorporation of novel ingredients in diet formulations offers a viable option for providing sustainable and nutritionally balanced livestock feed while mitigating environmental impacts of chicken systems in broiler chicken diets in the future. However, the technologies being developed to produce these novel ingredients are still in their infancy; much work is required to viably upscale these system processes so that production is efficient and competitive with imported soybeans. In some cases, their incorporation into the diets face technical challenges and legislative barriers e.g. the inclusion of insects in EU poultry diets.
Nalle 2010[123]	Broiler	Partial	Fava beans	Weight gain, feed intake and feed per gain of broilers fed fava bean diets were similar to those fed the maize–soybean meal diet. Birds fed fava bean diets had better ($P<0.05$) excreta quality scores than that of the basal diet. These results suggest that fava beans are good sources of energy and amino acids, and that fava beans can be included at 200 g kg−1 inclusion level as a partial replacement for soybean meal in broiler diets without any adverse effects on the performance.
Woyengo 2012[124]	Broiler	Partial	Zero-tannin fava beans	Zero-tannin fava beans had greater apparent ileal digestibility of amino acids and hence, it is a better source of amino acids for poultry than the conventional fava bean. The digestibility was similar to that of soybean meal, which means that the zero-tannin fava bean could replace a considerable portion of soybean meal in broiler chicken diets.
Laudadio 2014[125]	Layer	Partial	Low-fibre lucerne (alfalfa)	Partially replacing conventional soybean meal as protein source with low-fibre alfalfa/lucerne meal in the laying-hen diet can positively influence yolk quality without adversely affecting productive traits.
Laudadio 2010[126]	Broiler	Complete	Micronised dehulled peas	Pea level had no effect on the dressing percentage, the percentage of breast or drumstick muscles, and abdominal fat. The polyunsaturated fatty acid concentration in breast and drumstick muscles was significantly increased with the pea diet, whereas the saturated fatty acid was similar among treatments. In other words, the pea diet had a positive effect on the performance and meat quality of broiler chickens.
Laudadio 2011[127]	Broiler	Complete	Micronised dehulled fava beans	Full replacement of soybean meal with dehulled-micronized fava beans at 31% of the diet had no adverse effect on broiler growth performance and meat quality.

[122] Tallentire,C. W. et al. (2018) 'Can Novel Ingredients Replace Soybeans and Reduce the Environmental Burdens of European Livestock Systems in the Future?' *Journal of Cleaner Production* 187 pp. 38–47.

[123] Nalle,C. L. et al. (2010) 'Nutritional Value of Faba Beans (Vicia Faba L.) for Broilers: Apparent Metabolisable Energy, Ileal Amino Acid Digestibility and Production Performance' *Animal Feed Science and Technology* 156(3–4) pp. 104–11.

[124] Woyengo, T. A.and Nyachoti, C. M. (2012) 'Ileal Digestibility of Amino Acids for Zero-Tannin Faba Bean (Vicia Faba L.) Fed to Broiler Chicks' *Poultry Science* 91(2) pp. 39–43.

[125] Laudadio, V. et al. (2014) 'Low-Fiber Alfalfa (Medicago Sativa L.) Meal in the Laying Hen Diet: Effects on Productive Traits and Egg Quality' *Poultry Science* 93(7) pp. 1868–74.

[126] Laudadio, V. and Tufarelli, V. (2010) 'Growth Performance and Carcass and Meat Quality of Broiler Chickens Fed Diets Containing Micronized-Dehulled Peas (Pisum Sativum Cv. Spirale) as a Substitute of Soybean Meal' *Poultry Science* 89(7) pp. 1537–43.

[127] Laudadio, V. et al (2011) 'Productive Traits and Meat Fatty Acid Profile of Broiler Chickens Fed Diets Containing Micronized Fava Beans (Vicia Faba L. Var. Minor) as the Main Protein Source," *Journal of Applied Poultry Research* 20(1) pp.12–20.

2.2 An overview of UK pulse and legume production

The production and consumption of pulses are at an historic low in Europe, with the figure for legume production on arable land ten times smaller than the global average.[128] Pulse production reduced as a result of the intensification of agriculture, the simplification of crop rotations, loss of mixed farms and the rise in demand for meat, dairy and cereal products. Consumption of protein from pulses in the EU-15 Member States ranges from 0.1 g to 3.7 g per person per day, out of a total protein consumption of between 96 g and 119 g.[129] Currently, at EU level only about 8g of pulses per day per person are consumed[130]. The UK does better with around 14g of pulses per day per person on average[131]. In Canada the figure is 27.[132]

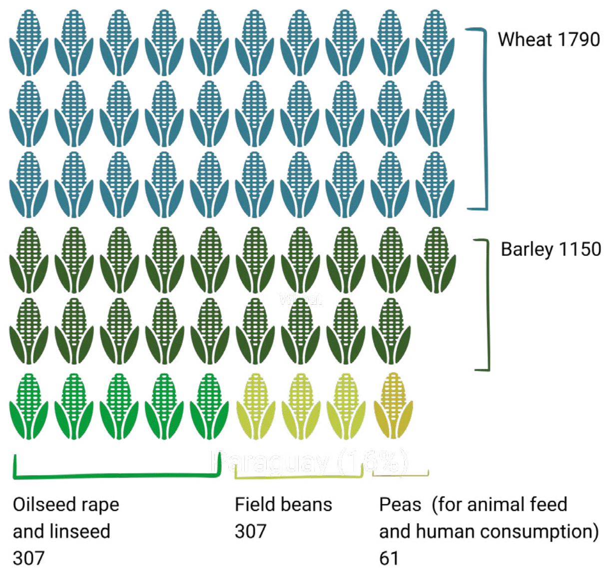


Figure 11: UK cropland use 2021 ('000ha)[133]

[128] Cusworth, G. et al (2021) 'Legume Dreams: The Contested Futures of Sustainable Plant-Based Food Systems in Europe," *Global Environmental Change* 69

[129] ibid

[130] Karlsson, J.O et al. (2021) 'Halting European Union Soybean Feed Imports Favours Ruminants over Pigs and Poultry," Nature Food 2(1) pp. 38–46

[131] Scarborough, P. et al. (2016) 'Eatwell Guide: Modelling the Dietary and Cost Implications of Incorporating New Sugar and Fibre Guidelines," BMJ Open 6(12)

[132] Magrini, M. et al (2018) 'Pulses for Sustainability: Breaking Agriculture and Food Sectors Out of Lock-In' *Frontiers in Sustainable Food Systems* 2

[133] UK Gov, National Statistics Chapter 7: Crops, 21st October 2022: https://www.gov.uk/government/statistics/agriculture-in-the-united-kingdom-2021/chapter-7-crops

In the UK, the cultivation of peas and beans utilised approximately 250,000 ha in 2017, just 4% of the 6.1 million ha cropland area, over half of which is given over to cereals[134]. In 2017, the UK produced up to 730,000 tonnes of pulses (580,000 tonnes of fava beans and 150,000 tonnes of dried peas)[135]. Production data from DEFRA for 2019 and 2020 are similar[136]. The UK also imports an estimated total of 185 thousand tonnes of chickpeas, lentils, and phaseolus beans (haricot, kidney, mung, etc.)[137]

In the UK, the cultivation of peas and beans utilised just 4% of total cropland area in 2017.

The small scale of pulse cropping in the UK in part reflects the abundance and availability of relatively cheap artificial fertiliser for the production of larger commodity crops such as wheat, barley and oilseed rape and a political focus that has concentrated on vegetable oil and carbohydrate production in the absence of a national protein strategy within the UK and the wider EU.[138] The focus on improving chemical inputs, cultivars and machinery has led to considerable improvements in the yields of cereals and oil seeds but has not gone any way in improving pulse yields.[139]

This has led to a large home-grown protein deficit for animal feed with reliance to fill that gap on the importation of soybean and soybean meal mainly from the Americas. The focus on domestic commodity carbohydrate production has led to the reduction in crop and crop rotation diversity, with the increased exclusion of lower yielding crops such as pulses despite their significant agronomic and environmental benefits.

Nearly all food-grade fava beans – between 15 and 30% of production dependent on whether they make food grade – are exported. The rest goes to animal feed. For field /dry peas, around half goes to feed and half to food, some of the best of which are exported.

The UK also produces an estimated 145 thousand tonnes of fresh peas annually, mostly sold as frozen peas, but needs to import another 10% to meet demand. At the same time, between 2 and 15% of the crops planted are left in the field because farmers were unable to harvest at the right time[140]. The UK also produces 26,000 tonnes of fresh beans and peas (runner and other beans in their pods), but to meet demand this is doubled through imports of crops such as mange-touts from Africa and South America.

[134] PGRO (2018) 'Blueprint for UK Pulses in a Post-Brexit World'

[135] ibid.

[136] UK Gov (2021) Agriculture in the UK: https://www.gov.uk/government/statistics/agriculture-in-the-united-kingdom-2021/chapter-7-crops

[137] Calculated using Legvalue data (https://www.legvalue.eu/publications/) and UK trade data (https://www.uktradeinfo.com/trade-data/ots-custom-table/)

[138] PGRO (2018) 'Blueprint for UK Pulses in a Post-Brexit World'.

[139] Cusworth, G. et al. (2021) 'Legume dreams: The contested futures of sustainable plant-based food systems in Europe' Global Environmental Change, 69

[140] Bruno K.S. et al. (2019) 'Market of Grain Legumes in the UK: Results of the EU-Project LegValue' *University of Applied Sciences*

2.3 Pulses and legumes in crop rotations

Agroecological methods demonstrate how including the use of legumes in rotations - in conjunction with no-till management or intercropping - can help improve the environmental performance of European farming whilst not jeopardising its food security. Legumes can become a point of consensus amongst stakeholders looking to stress how agroecological practices can help meet land-use objectives, and how key principles can be used to scale-up agroecological systems[141]. Another study found that in Scotland, the introduction of a legume crop into the typical rotation reduced external nitrogen requirements by almost half to achieve the same human nutrition potential[142].

In Europe legumes are enjoying a 'coming of age' moment; a maturity evident in a vast array of legume productivity research and their food processing potentials. Broad interest in crop rotation sustainability, drought resilience, flood risk mitigation, and resilience to pests and disease are animating this legume research agenda. The development and research processes that have improved wheat, rye grass, and oilseed rape yields are being applied to legumes with the purpose of making them a resilient and reliable tool for delivering on new food security and climate change challenges, to close yield gaps, and to recover ground they have lost to other cash crops in the last seven decades of agricultural research.[143] There may be potential challenges related to climate change in the future.

Policy can influence production: for example, there was an important increase in the production of legumes from 2014 to 2015 due to the new greening measures of the common agricultural policy (CAP) that started its implementation in 2015, implementing the "three crop-rule". This breaks with the conventional wheat-rape rotation, requiring every farmer who has more than 30 ha to grow at least 3 crops[144]. Despite this policy being well-intended, it was lacking in systemic design and was consequently reversed soon after it was implemented.

Recent market forecasts have documented a modest increase in legume consumption which is predicted to grow further due to the demand in health food markets[145] and the mainstreaming of vegetarian and vegan diets. A Research and Markets report forecast a 4.6% growth in the global pulse market from 2019 to 2027[146] motivated by markets for whole foods, meat-alternative products, bio-fortification with legume grains, and ready-to-eat meals targeted at health and environmentally conscious consumers. Most agree that Western consumers will remain more willing to embrace plant-based products over novel insect or cellular meat alternatives.[147]

141 Lampkin et al., 2015; Altieri et al., 2017 cited in Cusworth, Garnett, and Lorimer, "Legume Dreams."

142 Marcela P. Costa et al., "Legume-Modified Rotations Deliver Nutrition With Lower Environmental Impact," *Frontiers in Sustainable Food Systems* 5 (2021), https://www.frontiersin.org/articles/10.3389/fsufs.2021.656005.

143 Ibid.

144 Kezeya Sepngang, Bruno et al., "Market of Grain Legumes in the UK: Results of the EU-Project LegValue," 2019, https://www.legvalue.eu/publications/.

145 Cusworth, G., Garnett, T. and Lorimer, J., 2021. Legume dreams: The contested futures of sustainable plant-based food systems in Europe. *Global Environmental Change*, 69, p.102321.

146 Research and Markets, 2020 cited in Cusworth, Garnett, and Lorimer, "Legume Dreams."

147 Ibid.

Changing the agrifood system is further complicated by the interrelationships and influence of companies supplying farm inputs. As one expert summarised: "...a coherent organisation of agricultural production and food consumption has progressively been woven and locked-in around a technological paradigm based on agro-chemicals. This lock-in favours major crops such as wheat and soy, marginalising pulses. As a result, today the only way that the agrifood system can break out of this lock-in is if all the interconnected sectors that shape the agrifood system (such as those which breed seeds, produce fertilisers and pesticides, crop advisory services and harvest collecting, food processing, and retail) change together to favour a more sustainable system such as one with more pulses."[148]

The bulk of British cereals, barley, wheat and some oats are grown intensively in a 3-year rotation with oilseed rape[149], relying on fertilisers, pesticides, and tractor diesel. As pointed out by the government-commissioned independent food security report, this intensive farming system comes with a significant environmental impact "... due to the lack of biodiversity in conventional grain fields, damage to the soil through ploughing, environmental harms caused by fertilisers and pesticides, and the oil use embedded in fertilisers and field operations".[150] As we argue in this report, halting the use of soy in animal feed may also reduce the reliance on wheat and the damaging intensive arable farming system the UK is currently locked into. But to date the profit margin differences between otations that include legumes and those that don't are significant[151], so government policy will need to consider this when supporting change to healthier rotations.

[148] Marie-Benoit Magrini et al., "Pulses for Sustainability: Breaking Agriculture and Food Sectors Out of Lock-In," *Frontiers in Sustainable Food Systems* 2 (2018), https://www.frontiersin.org/articles/10.3389/fsufs.2018.00064.

[149] Farmers are increasingly looking for alternatives to oilseed rape because of the neonicotinoid ban, which offers an opportunity for increasing pulse production. See more here: https://onlinelibrary.wiley.com/doi/full/10.1002/ps.6361

[150] Ibid.

[151] https://www.agrii.co.uk/blog/rotational-change-requires-careful-planning/

2.4 Land use implications of increasing UK legume production

If the UK was to replace soy in animal feed with home-grown legumes and pulses there would be a significant increase in the area of land needed to grow these crops.

To form a better idea of what would happen if the UK were to grow more legumes to replace soy in animal feed, we carried out an analysis of the diet formulations of studies looking at the impact of replacing soy in feed with home-grown legumes. This analysis suggests that **using beans and peas not only reduces reliance on soy but also on the cereal component of the feed**. Although peas and beans have less protein compared to soy, they have more carbohydrates. Note that in another study replacing soy with insect meal alone, cereal contents did not reduce.[152]

An analysis of these studies which replaced soy with different legumes shows a consistent reduction in the amount of cereals needed as the legumes included a higher proportion of carbohydrates/starch than the soy.

Given the complexity of accurately calculating land use for these ingredients (accounting for yield variations of home grown and imported feed crops and accurately reflecting the land use of co-products such as wheat middlings or wheatfeed, soybean meal, distillers' grains amongst others), the following **findings have to be taken as an indication of a trend only**, not as a precise land use calculation as would be done when applying life cycle assessment (LCA) methodology.

Still, it is useful to analyse land use trends, bearing in mind that the UK has some of the highest wheat yields in the world (8t /ha) and that whole beans and peas are used as opposed to mostly the meal fraction of the soy.[153]

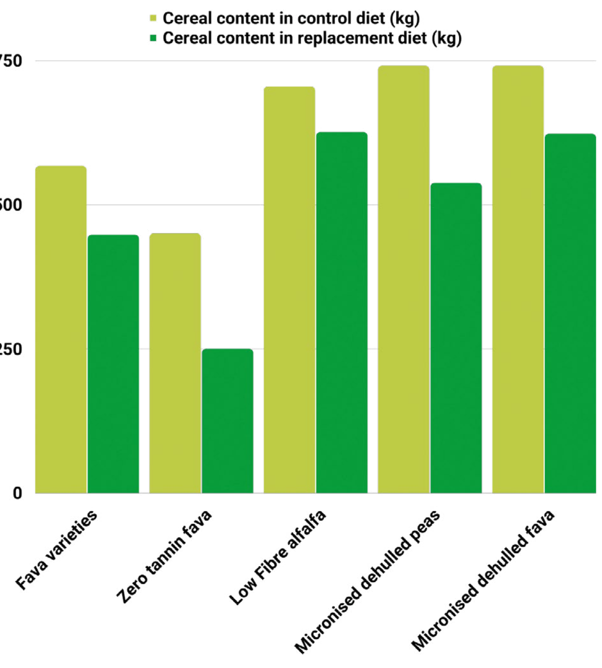


Figure 12: Reductions in cereal content of poultry feed (wheat, maize) when soy is replaced with different legumes[154]

[152] Heuel. M et al. (2021) 'Black Soldier Fly Larvae Meal and Fat Can Completely Replace Soybean Cake and Oil in Diets for Laying Hens' *Poultry Science*, 100(4)

[153] Please note that the following calculations only consider the land footprint of feed production and do not account for the land footprint of any other aspects of poultry and pig rearing. Given that outdoor pig production accounts for 40% of pig farming in the UK (AHDB: https://ahdb.org.uk/knowledge-library/outdoor-pig-production-arable-rotation), there is a significant land footprint additional to that of feed production.

[154] Each pair of bars in the graph comes from a separate study. From left to right: Nalle (2010) Woyengo (2012) Laudadio (2014) Laudadio (2010) Laudadio (2011). See Appendix 4 for table showing key ingredients.

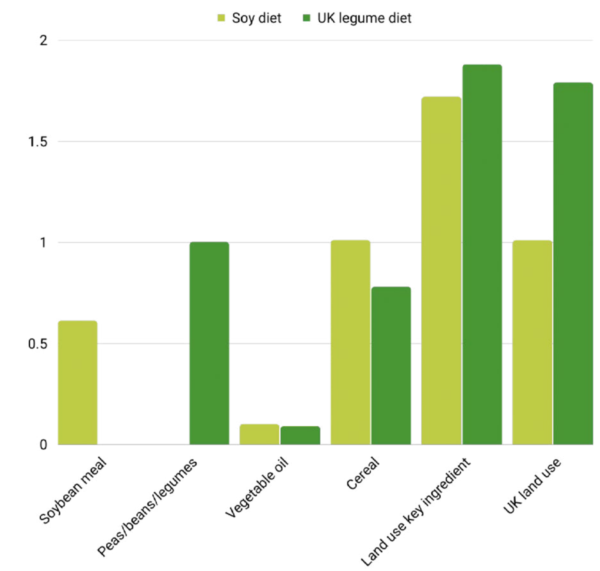


Figure 13. Land use (m2) per kg of poultry feed for soy feed and full UK legume replacement

Source: own calculation using feed data from studies above, and data for UK and South American crop yields

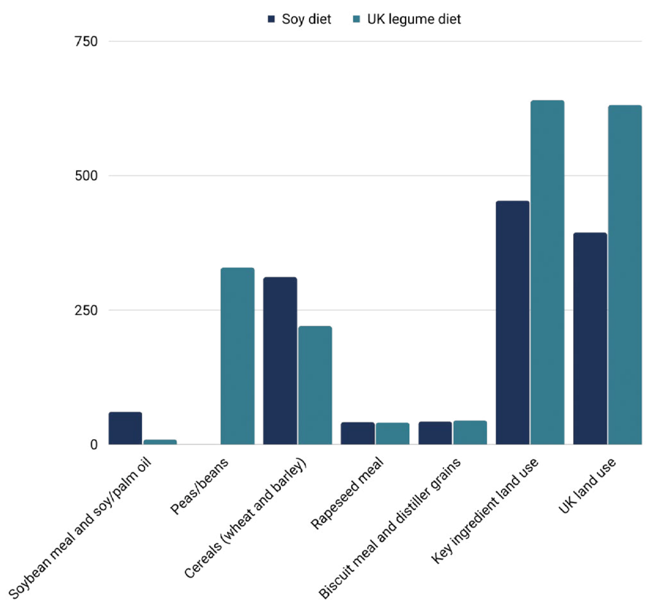


Figure 14. Consolidated estimated land use (m2) for key ingredients to feed one UK pig on a soy diet and replacement UK legume diet

Source: own calculation using feed data principally from the Greenpig project, and data of UK and South American crop yields

These findings show that with full replacement of soy with UK grown legumes overall land use for key ingredients would slightly decrease, but UK land use would increase.

For a graph showing a partial replacement of soy see Appendix 5.

For the pig diet, the estimates are based on the final diet formulation developed by the GreenPig project as an outcome of the different field trials[155].

These estimates would suggest that eliminating soy from pig and poultry feed without reducing overall pig and poultry production would:

a. **Increase the total land use in the UK for producing the replacement feed.**

b. **Proportionally, we are looking at an increase in legumes and a reduction in cereal crops, which overall could help establish more environmentally-friendly crop rotation systems.**

As discussed in section 2.3 there is a renewed interest in reintroducing legumes into crop rotations given the benefits for soil health, biodiversity and others. Growers working with Hodmedod already put this in practice with a simultaneous spring sowing of oilseed rape with barley and peas which after harvest can be turned straight into a mixed animal ration. Growing crops of different plant families together helps to utilise different ecological niches in the field, reduce pests, spread risk, increase biodiversity and look after the soil.

155 Houdijk, J (2012) supra note 104

2.5 Growing more pulses for human consumption

If we are to raise per person legume consumption to 75g per person per day - as per the Lancet recommendation - then the UK's supply of legumes will need to nearly double from 1 million tonnes to around 1.8 million tonnes.[156]

Fava Beans

There is currently almost no domestic human consumption of dry fava beans in the UK and so UK production is targeted at export for human consumption in Africa and the Middle East where they form a significant part of the staple diet. Egypt alone imports approximately 800,000 tonnes annually, traditionally taking around ¼ from the UK. Exporters are highly reliant upon the grower ability to control insect pests and produce bright appealing grains. In 2017 only 20% of the production met the required standard for premium prices and exports fell as a result. The remainder is destined for the salmon and animal feed industries. Pea production is intended for exports and human consumption in the mushy pea, canned and snack categories. Again poor quality grain affected by the weather or pest control problems will make its way to the pet food and animal feed markets. In 2017 just 10% of the marrowfat peas made the grade.[157]

How Canada became one of the world's leading legume producers

Through state sponsored breeding programmes in the 1970s and 80's, Canada developed high yielding and climatically suited cultivars of lentils and other legumes. The country is now one of the leading producers of many different legumes – primarily high-quality produce marketed for human consumption[158]. In 2017 Canada was responsible for over 50% of the world trade in peas and lentils – produced around 6 million tonnes. (3.1 million tonnes of peas, 2.6 million tonnes of Lentils, 322,000 tonnes of various dried beans, 92,000 tonnes of chickpeas).[159] In the Saskatchewan region, one of Canada's major arable areas, lentils account for 10% of the cropped area and other grain legumes for another 10%. In this region, the increased representation of legumes has improved farm profitability and environmental performance.[160]

[156] Pauline FD Scheelbeek et al., "UK's Fruit and Vegetable Supply Increasingly Dependent on Imports from Climate Vulnerable Producing Countries," *Nature Food* 1 (November 2020): 705–12, https://doi.org/10.1038/s43016-020-00179-4.

[157] PGRO, "Blueprint for UK Pulses in a Post-Brexit World."

[158] George Cusworth, Tara Garnett, and Jamie Lorimer, "Agroecological Break out: Legumes, Crop Diversification and the Regenerative Futures of UK Agriculture," *Journal of Rural Studies* 88 (December 1, 2021): 126–37, https://doi.org/10.1016/j.jrurstud.2021.10.005.

[159] PGRO, "Blueprint for UK Pulses in a Post-Brexit World."

[160] Cusworth, Garnett, and Lorimer, "Legume Dreams."

Almost all food grade broad beans are exported to North Africa where they are a staple (roughly between 80,000 and 180,000 tonnes per year, partly dependent on weather affecting production). Difficulties have increasingly been found in the human consumption export market due to reduced control of Bruchid beetles. The Bruchid beetle causes physical damage to the seed making it unsightly and undesirable. Higher temperatures, increased beetle activity, reduced availability of agrochemicals and increased pest resistance have made attaining the premium for this market more problematic in recent years.[161]

In France and Germany, fava beans are used as flour in bakeries. In contrast to peas, fava beans are not often fractioned – processed into its constituent parts such as proteins, starch and fibres – but with the development of the global plant protein market and rising demand for meat alternatives that situation is changing.

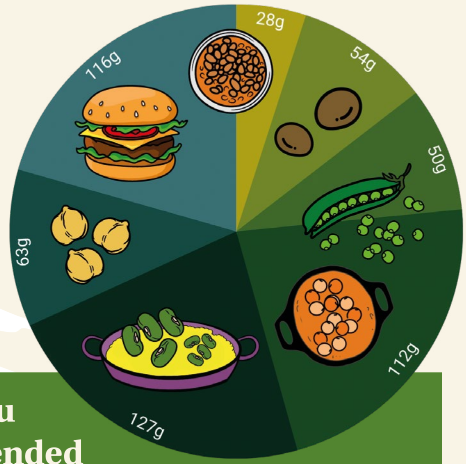
Dried peas

When it comes to field (dried) peas, the UK imports minor quality peas for feed – mainly from Russia, and exports some of its good quality peas. In 2017, more than 75 % of the exports went to Asia and Oceania. China (~5,000 t), Japan (~3,000 t) and Malaysia (~2,000 t) were the main countries where the UK´s field peas were exported. In the far East the best quality marrow fat peas are prized for snack consumption. That is a trend that is growing and is also developing in the European market too. It is not unknown for production to be exported only to return as a processed or coated pea snack.[162]

Nuts are also an important protein source in UK diets. The 2021 supply of all types of nuts was over 210 thousand tonnes, the bulk of which are imported, resulting in about 9 grams per person per day.

[161] Kezeya Sepngang, Bruno et al., "Market of Grain Legumes in the UK: Results of the EU-Project LegValue," 2019, https://www.legvalue.eu/publications/.

[162] Ibid.



Fresh peas

Fresh peas have different supply chains and nutritional characteristics to dry pulses. Fresh pea growing can be challenging because of the very narrow window in which fresh peas can be harvested to meet quality standards. Once this window is past, peas become "bypassed" crops which are either allowed to mature for seed production or destroyed in the field acting as green manure.[163] Hodmedod's is leading the way in not letting these peas (also called wrinkly peas) go to waste[164].

Baked beans

The UK also consumes haricot beans as baked beans. British and Irish people are the largest consumers of baked beans in the world, respectively 5.6 and 4.8 kg per capita per year. Baked beans were responsible for around 77% of the canned bean purchases in the United Kingdom in 2018/19.[165]

Sample menu for recommended 75g of pulses per day[166]

In order to estimate legume cropping areas and land sparing in the no food-feed competition scenario set out in the summary, we needed to develop a sample menu. This is just one random, but hopefully realistic, example to help form an idea of what it takes to eat the Lancet recommended amount of 75g per day of legumes[167]. It is by no means meant to be prescriptive. In this example an estimated 560 grams of legumes are consumed, a little more than the 525 grams weekly recommended amount.

- **Monday Dinner:** Carlin Pea Chili Bowl for lunch
- **Tuesday:** Add a serving of mushy peas (marrowfat peas) for dinner
- **Wednesday:** Red Lentil Dahl for dinner
- **Thursday:** Fava bean and carlin pea paella for dinner
- **Friday:** Falafels (made with chickpeas) for lunch
- **Saturday:** Two Soy Burgers for dinner
- **Sunday:** British Baked Beans for breakfast (made from fava beans)

[163] Ibid.

[164] Hodmedod's 'What a wonderful pulse! The amazon winkled pea': https://hodmedods.co.uk/blogs/news/what-a-wonderful-pulse-amazing-wrinkled-pea accessed 1st June 2023

[165] Dutch Ministry of Foreign Affairs, 'The European market potential for common dry beans' 5th January 2022: https://www.cbi.eu/market-information/grains-pulses-oilseeds/dried-kidney-beans/market-potential

[166] Based on author's *own calculation from Hodmedod's recipes (except the lentil dahl which is a BBC Food recipe and the soy burgers which are supermarket bought).*

[167] This report has used the Eat Lancet recommendation of 75g of legumes per person per day because to our knowledge it is still the most thoroughly researched reference diet combining health and environmental objectives and thus provides is with the most useful starting point *available* when considering the amount of pulses we might need to include in our diets. Also note that the Nature Food study (Karlsson, Johan O. et al. (2021) "Halting European Union soybean feed imports favours ruminants over pigs and poultry." *Nature Food* 2.1, 38-46.) found that 74g of legumes would need to be consumed per person per day in their calculations to maintain adequate protein in diets.

3

The Alternatives

Because of the finite amount of agricultural land we have in the UK, increasing the amount of cropland used to produce animal feed will inevitably result in trade-offs with the cropland used to produce food for humans. Moreover, the UK government's food security report states that "climate change poses a threat to high quality arable farmland and competition for land use is increasing"[168].

This is especially significant in the context of the UK's dependance on increasingly unreliable food imports from overseas. We need to prioritise producing food for human consumption, and feed our pigs and poultry on unavoidable waste, coproducts and byproducts that are inedible to humans. Preventing food waste at source must remain our absolute priority as this is vastly more environmentally beneficial than any other uses of food waste.

Default Livestock

Default livestock describes livestock that "don't compete for food with humans: they are fed on matter that humans can't or won't eat, mostly grass, leaves and waste materials, which they turn into food for humans."[169]

[168] UK Gov (2021) 'United Kingdom Food Security Report 2021: Theme 2: UK Food Supply Sources': https://www.gov.uk/government/statistics/united-kingdom-food-security-report-2021/united-kingdom-food-security-report-2021-theme-2-uk-food-supply-sources#united-kingdom-food-security-report-2021-theme2-indicator-2-1-2

[169] Fairlie, S. 'Eating The Platter Clean', *The Land Magazine:* https://www.thelandmagazine.org.uk/articles/eating-platter-clean

3.1 Treated food waste

More than any other farm animal, pigs have evolved to eat humans' leftovers. In comparison to poultry, pigs can digest a more diverse range of food industry by-products and leftovers[170]. Pigs are essentially descendants of wild boar whose omnivorous foraging habits near human settlements were capitalised upon by our ancestors who domesticated the pig as the quintessential domestic recycler. Pigs' appetites can therefore cope with almost anything; from food leftovers to animal viscera.

However, the 2001 Foot and Mouth disease outbreak in the UK and the more recent African Swine Fever outbreak in China are examples of the importance of ensuring leftovers are fed safely to pigs. Building on advice from microbiologists, epidemiologists, veterinarians and pig nutritionists, the REFRESH technical guidelines on animal feed[171] set out the key principles for producing safe feed from surplus food. To ensure safety, only omnivorous non-ruminant livestock should be allowed feed made from surplus food that may contain meat. Such feed should be sourced exclusively from specialist licensed treatment plants located off-farm and subject to stringent controls regarding heat treatment, acidification and biosecurity to ensure the feed is free from disease.

Legislation for the use of surplus food as omnivorous livestock feed that has been treated in specialist treatment plants has kickstarted a thriving surplus-food-to-feed sector in Japan. One of Europe's most important agricultural universities at Wageningen in the Netherlands leads the way on detailing the technical aspects to underpin such legislation in the EU. Australia, New Zealand and the US already permit the feeding of processed animal proteins to omnivorous livestock. And the South Australian government's research institute leads a multi-stakeholder project with participation of the pig industry to develop the underpinnings for relevant legislation there.

Aside from ensuring feed made from leftovers is disease-free, it is also crucial that no "market" for food waste is created through promoting its use as pig feed. **Prevention of overproduction of food at source must remain our absolute priority** because it is vastly more environmentally beneficial compared to any re-use of food waste once it is generated[172].

The food waste this report considers to be available as animal feed is only 9% of total food waste for the UK. This 9% excludes any surplus in primary production as this sector merits a separate approach to prevention at source and re-utilization of unavoidable surplus. This volume of surplus food also excludes household food waste as it may be too ambitious at this stage to legislate for its safe use in feed. The 9% therefore represent only the fraction considered difficult to avoid from manufacturing, retail and catering. We also took account of the fact that surplus from cereal and confectionery manufacturing and surplus bread is already turned into biscuit meal for animal feed by the former foodstuffs processing industry. Applying these principles to the volumes of food waste in the study by

[170] van Hal, O. et al. (2019) 'Upcycling Food Leftovers and Grass Resources through Livestock: Impact of Livestock System and Productivity' *Journal of Cleaner Production* 219, pp. 485–96.

[171] Luyckx, K. et al. (2019) 'Technical Guidelines Animal Feed: The Safety, Environmental and Economic Aspects of Feeding Treated Surplus Food to Omnivorous Livestock.' REFRESH Deliverable 6(7)

[172] Moult, J. A. et al. (2018) 'Greenhouse Gas Emissions of Food Waste Disposal Options for UK Retailers," *Food Policy* 77, pp. 50–58; Styles, D. et al. (2022) Climate Mitigation Efficacy of Anaerobic Digestion in a Decarbonising Economy' *Journal of Cleaner Production* 338

Styles et al.[173] results in around **320 thousand tonnes of pig feed that can be produced from this unavoidable food waste. This accounts for around 17% of the total volume of pig feed produced in 2021.**

As set out in the technical guidelines on the use of surplus food in feed[174], it is unlikely that such feed would be used without mixing with more conventional feed ingredients. However, food waste tends to be quite high in protein[175], and thus has significant potential as a feed ingredient. Also, for simplification, this report assumes that unavoidable food surplus from manufacturing, retail and catering is all fed to pigs after treatment to ensure its safety. Once treated, it may be possible to use some surplus food waste in poultry feed too.

173 Styles, David, et al. "Climate mitigation efficacy of anaerobic digestion in a decarbonising economy." Journal of Cleaner Production 338 (2022): 130441.

174 Luyckx, K. et al. supra note 167

175 Ibid.; Lalander, C. et al. (2019) 'Effects of Feedstock on Larval Development and Process Efficiency in Waste Treatment with Black Soldier Fly (Hermetia Illucens)', *Journal of Cleaner Production* 208, pp. 211–19; Gold, M. et al. (2020) 'Biowaste Treatment with Black Soldier Fly Larvae: Increasing Performance through the Formulation of Biowastes Based on Protein and Carbohydrates,'. *Waste Management* 102, pp. 319–29

3.2 Insects fed on biomass that is not suitable for consumption by humans or livestock

Insects may have a positive environmental impact when used directly for human consumption, if they are reared on feed which could not be fed to humans such as unavoidable inedible food waste. However, when used as animal feed, often in vast quantities, their environmental impact is often negative – particularly if they are fed on feeds which could have been fed directly to humans or livestock.

According to a key Life Cycle Assessment (LCA)[176], using larvae meal as animal feed results in "decreased land use" but "increased global warming potential and energy use", mostly because of the additional energy needed for growing and processing the larvae and the fact that you no longer use waste for bio-energy. Using renewable energy for insect farming may result in reduced global warming potential.

Two other studies[177 178] found that rearing insects on food or feed – that is diverting food that could be fed to humans or directly to livestock such as pigs and chickens – results in insect-feed associated with high environmental impacts. In addition, manure-fed insects (currently illegal in the EU) grew too slow and thus used too many resources during the growing stage to be of benefit[179]. An EFSA scientific opinion also noted that viruses that affect humans and farm animals can survive in insects, and thus feeds for insects containing meat would need to be heat-treated to make them safe, in the same way as normal animal feed[180].

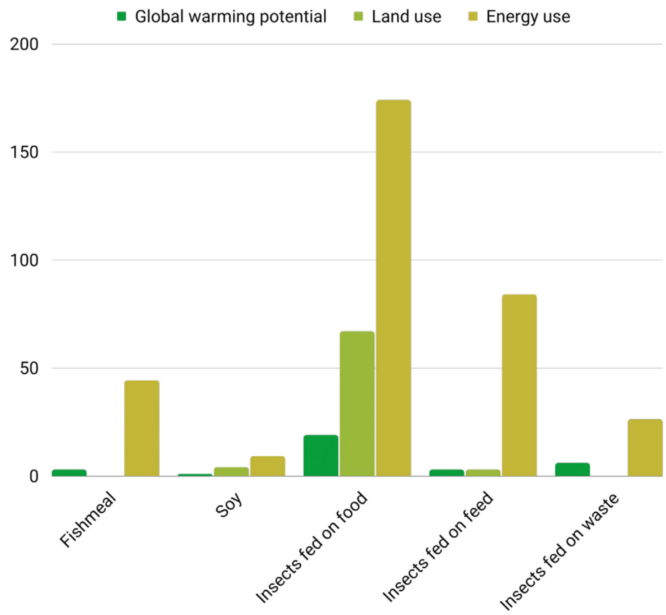


Figure 15: Comparison of environmental impacts of conventional livestock feeds with insects reared on food (edible to humans), feed and waste.[181]

In sum, research to date shows that compared to conventional feeds such as soy or fishmeal – both of which have significant environmental impacts themselves – insects are even less desirable from a sustainability perspective.

Insects only become of interest as a means by which they can keep unavoidable food waste, and other organic biomass that cannot be used in any other way, in the food chain. In other words, insects have to be seen as a last-resort waste management option, after food

[176] van Zanten, H.H.E. et al. (2015) 'Environmental Nuisance to Environmental Opportunity: Housefly Larvae Convert Waste to Livestock Feed," *Journal of Cleaner Production* 102 , pp. 62–69

[177] Bosch, G. et al. (2019) 'Conversion of Organic Resources by Black Soldier Fly Larvae: Legislation, Efficiency and Environmental Impact' *Journal of Cleaner Production* 222, pp. 355–63

[178] Smetana, S. et al. (2016) 'Sustainability of Insect Use for Feed and Food: Life Cycle Assessment Perspective', *Journal of Cleaner Production* 137, pp. 741–51

[179] ibid

[180] EFSA Scientific Committee (2015) 'Risk Profile Related to Production and Consumption of Insects as Food and Feed', *EFSA Journal* 13(10)

[181] Bosch, G. et al. supra note 173

waste, manure and other organic waste reduction has been maximised. This also means prioritising the direct use of mixed food wastes from retail, manufacturing and catering in pig feed, after specialist treatment to ensure safety. However, to our knowledge the UK has not yet changed legislation adopted when part of the EU placing legal limitations on feeding insects exactly with those feedstocks that may have some environmental benefit, as they could only be upcycled back into the food system by insects.

Insects only become of interest as a means by which they can keep unavoidable food waste and other organic biomass that cannot be used in any other way, in the food chain.

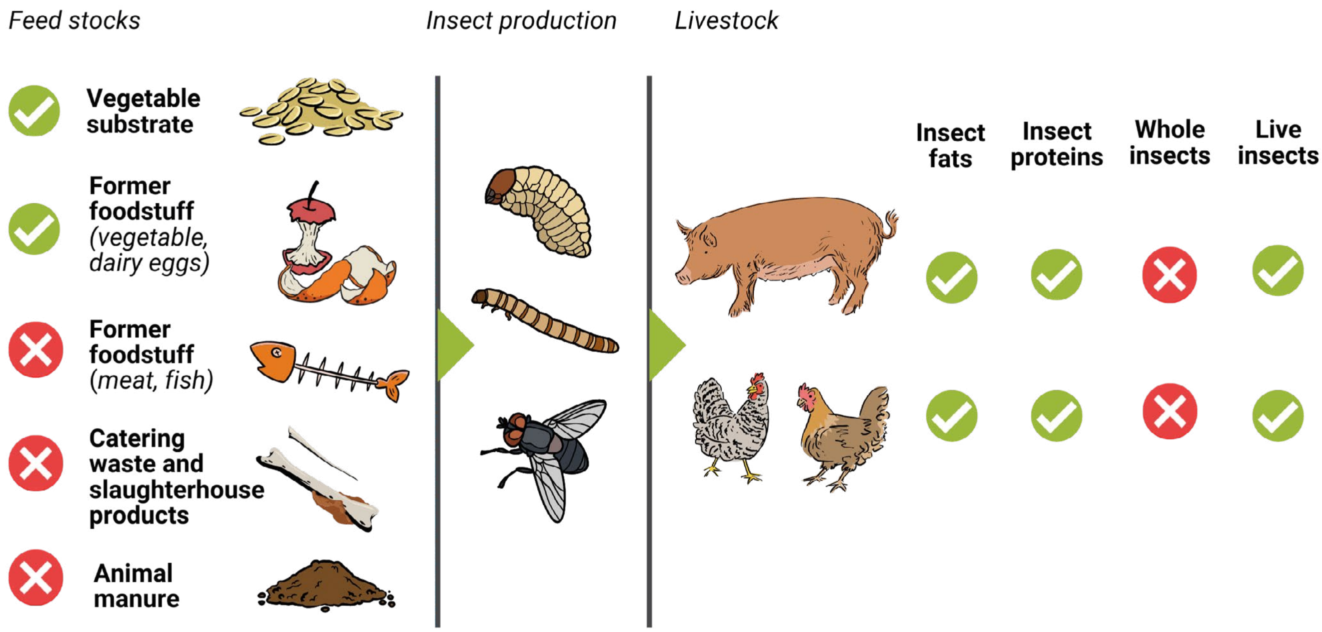


Figure 16. Overview of regulatory possibilities for using insect products as feed at EU level[182]

[182] Adapted from: IPIFF (2022) 'Guide on Good Hygiene Practices for EU producers of insects as food and feed': https://ipiff.org/wp-content/uploads/2019/12/IPIFF-Guide-on-Good-Hygiene-Practices.pdf

Black soldier fly larvae are an example of how insects can be used as a "tool" for unavoidable bio waste processing and treatment. Researchers have successfully grown black soldier larvae on food waste alone[183] and the resulting larvae meal is high in protein, though only small proportions of the food waste are taken up by the larvae (around 14% on a dry matter basis). On the other hand it is also possible to feed black soldier fly larvae with mixtures of biowaste that would otherwise be lost from the food supply chain, and such mixtures result in a much better conversion rate (between 20 and 30% of the dry matter of the waste is turned into larvae meal). Around one quarter to one third of these mixtures need cereal by-products from milling (such as wheat feed) but the inclusion of cereal by-products then allows for the upcycling of cow manure or human faeces alongside food waste. It is important that researchers further explore the environmental impacts of diverting cereal by-products from being fed directly to livestock to allow for the inclusion of manure in the black soldier fly feedstock (because larvae grow far too slow on manure alone for this to be a feasible option).[184] Ethical considerations on the welfare of these animals in rearing and slaughter needs further attention and regulatory control to avoid animal suffering.

Insects in Scenario 3

The 14% of poultry products that we calculate would be available in the UK after halting all soy imports for feed and optimising land use for sustainable protein production (Scenario 3), include using 1,777 thousand tonnes of household food waste[185] to grow black soldier larvae. In other words, after prioritising the prevention of food overproduction and waste at source, insects could be used as a means to upcycle unavoidable food waste and result in a poultry feed equivalent to about 7% of UK poultry feed production for 2021. To complete the protein rich larvae meal, this additional feed would require an estimated 280 thousand tonnes of cereal to be reallocated to feed production. This figure is considered in the calculation of the cereal reduction in the minimised food-feed competition scenario and the resulting land sparing potential (Scenario 3). More research also needs to be done to fully understand the greenhouse gas emissions from the larvae breeding process itself[186].

Soy feed in salmon farming

Feedback estimate that if Scottish salmon and prawn production is limited in size to be fed only on marine by-products (fish oil and fish oil from trimmings), this could save 57,000 tonnes of soybean meal, since shrinking the salmon industry would reduce demand for soy in feed[187]. Compared to current salmon production, the same micronutrients can be provided in this scenario (including omega 3) by increasing consumption of mussels, eating some small fish directly and some plant-based foods, alongside the reduced quantity of salmon and prawns. As well as reduced soy use, this scenario also makes it possible to leave 77% of wild-caught fish currently used for salmon and prawn feed in the sea.

[183] Lalander, C. et al. supra note 171

[184] Gold, M. et al. supra note 171

[185] Styles, D et al. supra note 168

[186] Parodi, A. et al. (2020) 'Bioconversion Efficiencies, Greenhouse Gas and Ammonia Emissions during Black Soldier Fly Rearing – A Mass Balance Approach', *Journal of Cleaner Production* 271

[187] Feedback (2020) 'Off The Menu;The Scottish Salmon Industry's Failure to Deliver Sustainable Nutrition' (London, 2020), 20.

3.3 Pasturing pigs and poultry to reduce feed intake

Pig and poultry diets can be supplemented by grazing on pasture or in forests with huge animal welfare and nutritional benefits to the stock. Free- ranging pigs and poultry enjoy being able to exhibit their natural foraging behaviour and supplement their diet with insects, worms and micronutrients and fibre. However, when designing these systems it is important to carefully analyse the land use impact of the pastures used and think carefully about stocking densities to maximise nutrient and ecosystem management.

Organic farming requires fields to spend some years under grass and legume cover to build fertility into the soil as part of a rotational cropping system. Pigs and poultry pastured onto these lays would be considered default livestock because they are layered into systems designed for arable production directly for human consumption.

Completely free-ranging pigs without any additional feed would need about 2 hectares **per pig**[188], requiring particular ecosystems such as the Dehesa oak-forests in Spain. According to the earlier land use calculations, 2 hectares of cropland could produce a peas / beans-based pig feed for more than 30 pigs. In the US, contemporary stocking rates to allow free foraging during the season whilst avoiding damage to pastures and plants, stand at 5 to 10 pigs per acre. This is roughly in line with the Soil Association guidelines on stocking densities of 18 porkers (weighing 35kg - 85kg) per hectare (or 7.5 pigs per acre)[189].

Whole grass is commonly used in organic pig rearing – with some organic pig farmers estimating that gestating sows with access to pasture consume up to 60% less feed than usual[190]. In the case of Paddock Farm, carefully managed rotational pasturing of groups of 60 to 80 pigs helped decrease feed intake from 2.25kg of feed /sow / day, to 1 kg of feed / sow / day during the grazing season. This reduction is in line with the percentage reported in the study above. Reducing feed intake by 60% during 58% of the year might result in a 35% feed saving over the year. *If* these feed savings rates are achieved on an overall stocking density of 10 pigs per hectare, and all the land concerned in the hypothetical scenario developed here was land suitable for arable cropping, then, **a pastured pig in this scenario uses over 1400 square metres of land compared to around 630 square metres of land by an indoor pig fed on a UK-grown legume diet.** This does not take into account the possible slower growing rate of pastured pigs. But it should be noted there are other environmental, public, social and welfare outcomes from this more multifunctional land use system.

As intensive indoor livestock farming systems have a whole host of additional welfare, environmental and other issues, **we do *not* advocate for turning pastured systems into indoor systems**. Rather, these preliminary calculations point to the fact that there are **large land use implications of converting indoor systems to pastured systems without reducing overall livestock numbers.** Our calculations are very basic using very sparse data, but they do chime with the findings of a key study on multi-species pastured livestock systems which concluded that the system they studied in the US **required 2.5 times more land** compared to conventional livestock systems[191].

188 Percy, A. *Happy Pigs Taste Better: A Complete Guide to Organic and Humane Pasture-Based Pork Production* (Chelsea Green Publishing, 2019).

189 Soil Association (2015) 'Pig Ignorant: Guide to small-scale pig keeping'

190 van Krimpen, M.M. et al. (2013) 'Cultivation, Processing and Nutritional Aspects for Pigs and Poultry of European Protein Sources as Alternatives for Imported Soybean Products' (Wageningen UR Livestock Research, February 2013), 25

191 Rowntree, J.L. et al. (2020) 'Ecosystem Impacts and Productive Capacity of a Multi-Species Pastured Livestock System', *Frontiers in Sustainable Food Systems* 4

Given so few pigs and poultry are pastured, there is little evidence to show how multi-functional this type of land use would be, in the sense of biodiversity, carbon and water benefits that would follow from pastured pig and poultry systems at scale.

If not managed properly, pastured poultry can damage vegetation and cause build-up of nutrients and microorganisms, including human foodborne pathogens such as *Campylobacter* and *Salmonella*.[192] Faecal matter is excreted directly onto the field and not subjected to waste management practices to ensure the inactivation of pathogens,[193] which may enter nearby lakes and streams.[194] Some mitigation strategies include vegetative buffers in high runoff areas.[195] Individual pastured poultry systems may have only a minimal or acute impact; however, when considered as a whole within a region, these systems, could have an unintentional larger impact depending on the number of birds on pasture[196]

This means that similar to the point above on pastured pig systems, pastured poultry systems are of interest but again only if we consider the necessary reductions in livestock numbers this would require to avoid unintended consequences on ecosystems, water and land and the use of pasture which is part of arable rotational systems or sustainable forest management. Ultimately, when farmed animals are managed in a way that suits their ecological role and/or niche, they can play hugely positive roles within our food systems. When this is not the case, problems can occur that require complex trade-offs.

Nutritional aspects of pastured pigs and poultry

In a study of free-range-pastured poultry broilers, pasture intake was found to decrease carcass yield[197] – with restriction of cereal-based feed intake leading to an increase in relative leguminous pasture intake from 1.6 to 4.9% of total intake, on a dry matter basis[198]. Another study found that organic broilers were able to get 7% of their recommended amount of protein through consuming grass-clover from pasture[199]. Fresh grass can also contribute 12-13% of the total dry matter intake for laying hens[200]. Grass has different digestibility depending on when it's harvested – varying from negative digestibility for grass hay to 47.8% digestibility for grass silage[201]:

[192] Fanatico, A. C. (2006) 'Alternative Poultry Production Systems and Outdoor Access' Fayetteville, AR: ATTRA publication; National Center for Appropriate Technology.

[193] Ferguson, C. M. et al. (2007). 'Field scale quantification of microbial transport from bovine faeces under simulated rainfall events.' *J. Water Health* 5, pp. 83–95

[194] Metcalf, J. H. et al. (2014) 'Bacterial content in runoff from simulated rainfall applied to plots amended with poultry litter' *Int. J. Poult. Sci.* 13, pp. 133–137

[195] Adrizal, A. et al. (2008) 'Vegetative buffers for fan emissions from poultry farms: 2. ammonia, dust and foliar nitrogen' *J. Environ. Sci. Health B.* 43, pp. 96–103

[196] Rothrock, M.J. et al. (2019) 'Pastured Poultry Production in the United States: Strategies to Balance System Sustainability and Environmental Impact' *Frontiers in Sustainable Food Systems*, 3

[197] Ponte, P. I. P. et al. (2008) 'Restricting the Intake of a Cereal-Based Feed in Free-Range-Pastured Poultry: Effects on Performance and Meat Quality' *Poultry Science* 87 (10)

[198] ibid.

[199] Van Krimpen, M.M. et al. (2013) 'Cultivation, processing and nutritional aspects for pigs and poultry of European protein sources as alternatives for imported soybean product's (No. 662). Wageningen UR Livestock Research.

[200] ibid

[201] ibid

	Unit	Fresh grass (young)	Fresh grass (older)	Grass Sialge	Grass Hay	Lucerne Hay
Dry matter content	g/kg	166	198	533	891	892
Protein content	g/kg dm	148	108	194	62	150
Protein digestibility	%	45	36.6	47.8	-26.7	38.5
Intake	kg dm/sow/d	0.79	0.85	1.12	0.71	1.01
Digestible protein intake	g/sow/d	53	33	104	-	58

Figure 17. Intake and digestibility of different organically produced grass sources and Lucerne hay in organic housed gestating sows.[202]

One study that looked into grass protein in pig production found that feed with a higher amount of green protein will result in a high amount of polyunsaturated amino acids, especially omega 3 amino acids, in the meat.[203] This results in a healthier amino acid profile but may also increase the risk of rancidification and an unpleasant aftertaste, which will negatively affect the meat quality.

Studies looking at grass clover as partial replacement in pig diets have shown that there was an increased grass clover intake in the low protein group, as they consumed 14% more grass than the sows fed the normal protein compound feed. It was possible to reduce the protein content of organic compound feed in the summer time as grazing pregnant sows obtained 16-17% of their daily SID lysine requirement from the sward in mid and late gestation. In conclusion, the daily protein- and amino acid requirements were met by feed and grass consumption during pregnancy but not in early and at peak lactation due to insufficient feed intake.[204]

[202] Table adapted from Van Krimpen at al, supra note 195

[203] Byrne, J. 'Putting Grass Protein to the Test in Pigs' feednavigator.com, March 7, 2019: https://www.feednavigator.com/Article/2019/03/06/Putting-grass-protein-to-the-test-in-pigs

[204] Eskildsen M. et al. (2020) 'Grass Clover Intake and Effects of Reduced Dietary Protein for Organic Sows during Summer', *Livestock Science* 241

Integrated Crop-Livestock Systems

A meta-analysis[205] of 66 studies compared crop yields in Integrated Crop-Livestock Systems (ICLS) to yields in unintegrated controls across 3 continents, 12 crops, and 4 ruminant livestock species, commercial, large- or medium-scale settings. **The analysis found that when grazing is included in the cropping system design, average crop yields are the same as yields in ungrazed systems across a wide variety of environmental and management contexts.**

Successful ICLS–especially ICLS that do not increase input use relative to non-integrated systems–can generate more product per unit of land area or input, thereby reducing the need for agricultural expansion into intact native ecosystems. Grazing can be coupled with crop production to generate increases in productivity per unit land area without great risk of compromising crop yields but these outcomes are undoubtedly contingent on the use of best grazing management practices such as appropriate stocking rates and timing of management operations.

Four types of ICLS were identified: 1) forage rotation, or a multi-year rotation of crops with semi-permanent pasture or turf grazed by livestock (also known as sod-based rotations); 2) cover crop grazing, or an annual rotation of a cash crop with an off-season grazed forage; 3) stubble grazing, or livestock grazing of crop residues left over after harvest; 4) dual-purpose crops, or crops that are grazed by livestock in early phenological stages and subsequently allowed to mature for grain harvest[206] .

Clover, lucerne and green manures are part of rotation regardless of feed use as they help farmers move away from synthetic nitrogen fertilisers. could be counted as co-products for this – basically like green manures that happen to be great feed for pigs.

[205] Peterson, C.A. et al. (2020) 'Commercial Integrated Crop-Livestock Systems Achieve Comparable Crop Yields to Specialized Production Systems: A Meta-Analysi', PLOS ONE 15(5)

[206] ibid.

3.4 Co-products of legumes

After harvest, pulses go through a number of cleaning and processing stages in order to make them ready for human consumption. At each stage co-products are generated that may be suitable for animal feed.

Where pulses are destined for sale whole, cleaning involves a first stage removal of stones, very damaged pulses and any extraneous vegetable matter; this co-product tends only to be suitable for anaerobic digestion or composting. Further processing to remove discoloured and otherwise out of specification pulses generates co-products (screenings) that are suitable for animal feed.

Where beans and beans are then decorticated (skins removed) and split through a process of abrasion significant quantities of 'flour', a mix of seed coats and dust, is generated. By this point in processing only 55-65% of the pulses that were delivered for cleaning are destined for human consumption. The majority of the remaining 35 to 45% is sent for anaerobic digestion or animal feed.

Whilst screenings are relatively easy to sell into the feed market, the 'flour' tends to go for anaerobic digestion because of the variability of the product and difficulty in handling it. With more research and development to make the flour more easily processed by feed manufacturers it could be used for pig and poultry feed. For example, pea flour mixed with wheat bran as a feed for insects has been shown to work. The use of processing co-products for feed is likely to be critical if an increase in the domestic production of pulses for human consumption is to be economically and agronomically viable.

It's ironic that some of the properties of pulses which are increasingly understood to be good for human health have historically been regarded as undesirable by feed compounders and plant breeders specialising in animal nutrition. For example, resistant and retrograde starches (RS) which are digested lower in the gut have been demonstrated to be important for human metabolic health, but in animal feeds they've been characterised as indigestible carbohydrates. Likewise polyphenols, whose role in human health is well described, have been regarded by the feed industry as undesirable 'antinutritional' factors because their antioxidant properties can reduce protein digestibility and mineral absorption.

In part informed by human nutritional science, RS, polyphenols and other antinutritional factors are being re-examined by those working in animal health and nutrition, in particular their potential role in disease control and reduced antibiotic use. This coming

together of nutritional priorities may well aid legume breeding efforts, which tend to be focused on yield and animal feed demands over human taste and nutrition preferences, making it easier to market co-products for feed and supporting the development of new varieties higher in compounds such as RS.

3.5 A note on breeds

Genetic selection is a crucial tool in the livestock industry. For example, swine geneticists were the first to use genetic markers to remove defects and to select for improved feed efficiency, growth, meat quality and increased litter size.[207] Genetic selection for feed efficiency goes hand in hand with the development of ever more precise feed formulations, reliant on high quality feed ingredients such as soya and synthetic amino-acids. Although slower growth rates might theoretically be offset by lower feed costs, the requirements of modern fast-growing pig breeds mean that for the mainstream pig industry, little compromise on nutrition is possible.

Conversely, if we are to feed pigs on unavoidable food waste and co-products we need to consider the pig's ability to thrive and breed on more diverse low-quality feeds. For example,some of the Japanese pig farmers using 100% food waste based feed work with the slower growing, but more prolific breeding Meishan pigs.[208] It has been suggested that Meishan pigs are resistant to some diseases and able to consume large amounts of roughage[209]. Some breeds may indeed be more tolerant of short-term nutritional variations.[210] Similarly another study[211] compared low-, medium, and high-productive pig systems and found that low-productive pigs provided the most optimal conversion of available low-cost feeds such as surplus food. When this study considered only high-productive animals, pigs could no longer use surplus food to meet their specific nutrient requirements.

With regard to chickens, there is a lack of research on the ability of different breeds to thrive on more diverse, lower-quality feedstuffs, but there is no doubt that slower growing breeds are more robust and adaptable. For example, one study found that slower-growing breeds in comparison with fast-growing ones showed more active behaviour, fewer heart abnormalities, less tendon degeneration, lower mortality and a lower culling rate.[212]

To summarise, it is clear that a reorientation of genetic selection to poultry and pigs best able to thrive on a more diverse set of surplus feedstuffs is an important part of creating more sustainable, soy-free pig and poultry farming.

207 Mote, B.E. and Rothschild, M.F. (2020) 'Modern genetic and genomic improvement of the pig. In Animal Agriculture (pp. 249-262). Academic Press.

208 Luyckx, K., et al. (2019) 'Technical Guidelines Animal Feed: the safety, environmental and economic aspects of feeding surplus food to omnivorous livestock.' REFRESH D6.7: https://eu-refresh.org/sites/default/files

209 Johnson, M. (1996) 'Meishan Swine. Breeds of Livestock by Oklahoma State University.' :http://afs.okstate.edu/breeds/swine/meishan/.

210 Luyckx, K. (2018) 'Expert Seminar on the Risk Management of Using Treated Surplus Food in Pig Feed'. 'REFRESH Task 6.3.3, Wageningen University & Research, Netherlands: http://eu-refresh.org/sites/default/files/REFRESH%20animal%20feed%20expert%20seminar%20report%20final%2012.04.18.pdf

211 Van Hal, O. et al. (2019) 'Upcycling food leftovers and grass resources through livestock: impact of livestock system and productivity. Journal of Cleaner Production' 219, pp.485-496.

212 Sossidou E.N. et al. (2011) 'Pasture-Based Systems for Poultry Production: Implications and Perspectives," *World's Poultry Science Journal* 67(1)

Scenarios

The following scenarios are hypothetical and have resulted from calculating the impact on protein supply and cropland use from halting soy in UK animal feed supplies. They take into consideration variables including land-use, nutrition and imports.

Scenario 1: Replacing soy in pig and poultry feed with home-grown legumes

With regard to home-grown pulses as soybean alternatives, simply replacing all imported soybean meal with fava beans and peas[213], would significantly increase the share of cropland needed for animal feed production.

This study estimates that for the UK we would need **an additional 60% of land to produce the same amount of pig feed if soy were no longer available, compared to the amount of land we use right now for pig feed production.** For poultry, we would need **an extra 78% of land to produce a similar volume of poultry feed** that complies with the nutritional requirements described in research studies testing the complete replacement of soy in poultry diets (see section 2.4), **compared to the amount of land we currently use for poultry feed production.**

This *extra* cropland would principally be used to grow fava beans and peas, but as these have relatively less protein and more carbohydrate compared to soy, we would need to grow more of these pulses compared to the volume of soy imported. Moreover, pig and poultry diets with beans and/or peas would have relatively less cereal (to balance the fact that soy doesn't contribute as much carbohydrate in a conventional diet). Growing more legumes has many advantages, but because cereals like wheat have a much bigger crop yield per hectare of land compared to beans and peas, land use for home-grown animal feed diets is pushed up.

Scenario 2: Replacing soy in pig and poultry feed with home-grown legumes, without increasing UK cropland area

Our starting premise is that we cannot justify creating additional cropland in the UK to replace soy. Already over 70% of UK land is used for agriculture[214], and 55% of domestic cropland is used for growing animal feed[215]. We should also avoid unintentionally shifting import dependency from feed crops to food crops, increasing land demand elsewhere, with potential negative impacts. Thus, we estimated how much pig and poultry feed could be produced **if we were to halt all imports of soy for feed, and *simultaneously* ensure that no additional land would be used for home-growing the replacement feed.** In addition, the UK imports 34% of the pork it consumes, so we also want to avoid indirect imports of soy via pork produced abroad.

Bearing these issues in mind, we estimate that **pork supply in the UK would need to be reduced by 41%. For poultry**, where the UK is roughly self-sufficient, we would need to reduce supply by 44% if we are to halt all soy imports for feed and not increase the land used for producing poultry or pig feed. Other benefits from reducing meat production (such as emissions and pollution from manure, antibiotics use) are discussed elsewhere, for instance see Eating Better's report on chicken.

The problem with **this scenario**, where we replace soy in feed with fava beans and peas – without increasing cropland used for feed – is that there **is no land freed up to replace the proteins** that were lost through the reduction in supply of pork and poultry products.

[213] This scenario does not **eliminate embedded soy imports**, only soy imports which are used to feed pig and poultry in the UK.

[214] DEFRA, "United Kingdom Food Security Report 2021: Theme 2: UK Food Supply Sources."

[215] H. Harwatt and M. Hayek, "Eating Away at Climate Change with Negative Emissions: Repurposing UK Agricultural Land to Meet Climate Goals," *Cambridge, Mass.: Animal Law and Policy Program, Harvard Law School*, 2019.

Scenario 3: Replacing soy in pig and poultry feed with by-products and food waste only, without increasing UK cropland area, and ensuring adequate human protein intake through increased pulse production

Finally, we asked whether there might be a different way of using UK cropland to meet our protein needs. There are many possible answers to this question, so we developed one possible scenario based on two premises:

a. **what would happen if we attempted to avoid food-feed competition over cropland?**

b. **what would it take to supply sufficient pulses for each person in the UK to be able to eat the recommended 75g of pulses per day?[216].**

To start with, we felt that it would be important not to halt imports of pulses difficult to grow in the UK such as chickpeas and kidney beans to ensure variety in a diet high in pulses. In the same vein, some soy imports *for food alone* might be desirable. In our calculations, overall soy imports could be reduced to just 12% of current levels, and supply soy for making foods like tofu and burgers. Reducing demand for soy as drastically as this may allow us to source soy responsibly.

If we were to eliminate any food-feed competition, livestock would have to be raised on food surplus – ie. food waste and by-products. We could still have some eggs, poultry and pork in our diets by using unavoidable food waste: Assuming that we prioritise the prevention of the overproduction of food at source, and the prevention of food waste in all stages of the supply chain, we calculate that around 9% of mixed food currently wasted in manufacturing, retail and catering might be available to turn into feed. After being heat treated to ensure safety, such food waste could replace around **17% of current pig feed**. Moreover, the co-product of splitting some of those extra beans and peas in our food, could be used in feed. Accounting for the halting of imports of pork, in this scenario we would need to **reduce pork consumption by 82%** - this is based on halting all pork imports (34%) and a 73% reduction in UK pork production.

For poultry, difficult to avoid household food waste could be fed to black soldier fly (BSF) larvae which researchers have found to be an excellent replacement of soy in poultry diets. Using these larvae plus some co-product from bean and pea splitting but avoiding purpose growing pulses for feed would mean that **poultry consumption would be reduced by 86%**. For both alternatives, new legislation would need to be passed to ensure that prevention of food waste at source and feed safety remain the priority whilst legalising the use of mixed food wastes in non-ruminant and insect feeds.

In the context of such a reduction in pig and poultry meat, we would need to increase our consumption of plant-based protein. In line with Lancet recommendations, our calculations estimate that we would need to **increase our average consumption of pulses from current levels of 14g per day, to 75g per day. This means that UK cropland used for pulse production would need to increase by 190 thousand to a total of 440 thousand hectares** (compared to 250 thousand ha currently). This might seem a lot, but currently only 4% of UK cropland is used for pulses. In addition, we would **free up over 540 thousand hectares of cropland**, as cereals grown on this land would no longer be needed in pig and poultry feed.

Leaving out fresh peas and fresh beans, UK legume production would increase from around 700,000 tonnes currently, to over 1.1 million tonnes and all these legumes would be consumed as food. Only around 100 tonnes of co-products from splitting peas and beans for food would be available for animal feed.

[216] We have used the Eat Lancet recommendation of 75g of legumes per person per day because to our knowledge it remains the most researched reference diet aiming to balance health and environmental objectives. We have not found further research that replaces the depth and breadth of expertise of the scientists who developed the Eat Lancet reference diet.

Comparison with EU-level study[217]

A key study in the journal Nature Food looked at the same issue at EU level: how to halt soy imports for animal feed without increasing the cropland used for home-growing feed while also ensuring a sufficient supply of protein, fat and oil (the oil question is interlinked and discussed below in the report) and key micronutrients. We report this study here as it provides a useful comparison to our own scenarios and includes further information on potential unintended consequences regarding vegetable oil production.

The study found that EU **pork production would need to be reduced by 51% and poultry meat production by 68%**. Adopting such reductions (higher than those we found in our Scenario 2 but lower than Scenario 3) would allow for some pork and poultry to be produced but simultaneously produce enough pulses within the EU to supply each person with their overall protein requirements. As this study was done at EU level (including the UK), it is assumed that in this scenario pork imports, currently making up 34% of UK consumption[218], continue.

Replacing all imported soybean meal with EU-grown pulses and soybean would increase the share of EU cropland devoted to animal feed production, reducing the area available for growing crops for human consumption. This could unintentionally shift import dependency from feed crops to food crops, increasing land demand elsewhere, with potential negative impacts. Researchers created different land use scenarios in which we avoid such an unintended shift.

In the first scenario of the EU study, replacing imported soy with EU-produced soy, fava bean, pea and lupin, without using more than the 48% of EU cropland currently used for feed cultivation, reduced demand for non-EU cropland (mostly soy) by 11 Mha and meat from pigs and poultry by 49% and 34% respectively. Egg production was maintained. 17% of current (real) EU soy imports would have to be consumed directly by humans to maintain overall energy and protein balance, and legume consumption would be 45g per person per day. Due to reduction in demand for soybean meal, more palm oil would need to be produced needing an additional 2 million hectares of land in vulnerable ecosystems.

In the second scenario, to avoid this additional palm oil production, we could use cropland freed up due to reduced meat production for rapeseed oil production instead (if we halt the use of imported soy as feed, then overall there is less protein available as feed, this reduces pork and poultry production, which in turn reduces demand for feed cereal production). Avoiding imports of soy for feed altogether, whilst simultaneously preventing any increase in palm oil imports, would mean that we have 41% less pork and 71% less poultry. Pigs are better at digesting rapeseed meal, and thus favoured in this scenario compared to poultry. To meet human protein demands we still need to import 22% of current soy imports, but to eat directly. Legume consumption would be 55g per person per day.

A third scenario attempted to eliminate both soy and palm oil imports without increasing EU cropland by converting 3 million hectares of EU cropland to the production of soy, broad bean and peas. Pork and poultry would need to be reduced by 51% and 68% respectively. But if no additional cropland is to be used, the land spared through this reduction is not enough for all rapeseed oil production, and we would still need to import additional palm oil requiring 1 million ha of land. So, soy imports were eliminated altogether but not palm oil imports. Even so, this scenario achieves maximum reduction (from 15 million ha to 1 million ha) of protein and oil crop land footprint outside the EU (compared to 3 or 4 million hectares in the other two scenarios). Legume consumption would be 74g per person per day in this most land efficient scenario.

[217] Karlsson et al., "Halting European Union Soybean Feed Imports Favours Ruminants over Pigs and Poultry."

[218] DEFRA, "United Kingdom Food Security Report 2021: Theme 2: UK Food Supply Sources."

Conclusion

This report has shown that our reliance on soy for pig and poultry feed in the UK is unsustainable and contributing to environmental destruction overseas. Furthermore, given current increases in global demand, supply chain soy certification initiatives are proving unable to limit deforestation, meaning that there is an urgent and obvious need to reduce our demand for soy, and the UK should focus on the animal feed supply industry to address this.

However, the modelling in this report demonstrates that replacing soy in animal feed with home-grown legumes would have significant implications for land-use in the UK. If the UK was to replace soy with legumes within the current cropland area, not only would it require a reduction in consumption but it would also result in a protein deficit in our diets.

We need to move towards scenario 3 in order to produce more sustainable pig and poultry, where food-feed competition is avoided for food security reasons, and people's diets are supplemented by increased legume consumption.

The EU level study demonstrates what could happen on a European regional level – allowing trade of meat and feed products with Europe.

In order to reconcile nutritional, livelihood and environmental needs we would need to transition to a pig and poultry sector which makes the most of food waste, by products and biomass that is inedible to humans, and prioritise UK cropland for growing food for human consumption.

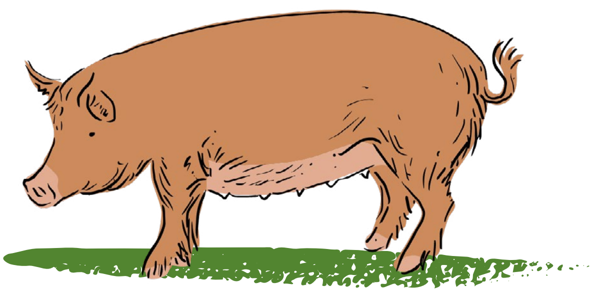
This transition will inevitably be grounded in a reduction of the amount of pig and poultry meat that we consume, which means we will need to produce more plant-based protein to supplement our diets. This could offer opportunities to farmers looking to build resilience and diversity in their their businesses.

Policy Recommendations

We have the following policy recommendations to help the transition towards a sustainable feeds scenario.

We stress that all of the below policies:

- Should not exacerbate feed-fuel-food land use competition
- Should support an overall reduction in the consumption of pork and poultry meat and eggs
- Should support localised food systems and put control in the hands of farmers, not large corporations
- Should be in line with a broader just transition towards a more sustainable food and farming system and the implications this will have on employment and training opportunities across all food industries.



1. Agree government industry pathway away from soy

Government needs to work with experts, industry and society, to set feed pathways (in climate and other relevant policy EIP, Net Zero etc) with annual targets for reducing demand for soy and reducing demand for pork and poultry. This should include

- Climate Change Committee rapid pathways for reducing deforestation, changing diets and government actions
- Net Zero strategy to include specific targets, including for a just transition to reduce overall UK meat consumption[219]
- Environment Improvement Plan – which lays out Government's goals for improving the environment, matched with interim targets to measure progress – to be amended to cover action on farms involving grain and protein imports
- New policy on trade deals to ensure ban on imports of deforestation-risk products (not only from illegally deforested land)

2. Full transparency in supply chains on feed and meat (embedded)

We need new mandatory transparency rules for corporations giving fully open data on sourcing of soya and imported beef given the interrelationship (see section 1.2)

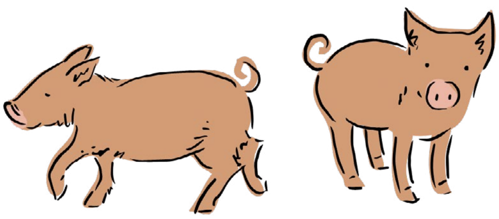
- This means accelerating the Defra Data Transparency project via stronger Food Data Transparency Partnership with broader membership including non industry partners
- Set targets for mandatory reporting on embedded impacts on land use, biodiversity and climate of all food and feed imports

219 Specific targets relating to the production and consumption of ruminant animal products are outside of the scope of this report, but other meat and livestock systems and their mpacts are well covered in other research papers.

3. New domestic feed sources to replace soya

We need to develop policies including research and development, financial support and private investment incentives to increase the sustainable supply of feed legume co-products, insect feeds etc without increasing feed crop land. This should include:

- Plans to deliver via support and training, more peas, beans, and other legumes such as lentils, including R&D to develop UK-adapted varieties within land and sustainability limits. While the primary purpose of this production increase should be human consumption, an overall increase can supply co-products and unavoidable surplus to animal feed
- Reform Swill Feeding regulations to ensure safe use of unavoidable food waste properly treated in specialist facilities (with rapid learning from other countries such as Japan, and the R&D currently taking place in the Netherlands[220] and Australia) and after significantly strengthening legislation to prevent food waste at source
- Legislation and support for using insects as a last resort treatment of unavoidable household food waste, manure, and other unavoidable biomass that cannot be consumed directly by humans or other farm animals and regulate to ensure humane, safe production and slaughter



4. Strong, clear animal product demand side policies

Policies will be needed to deliver a reduction in demand for pork and poultry products using unsustainable feeds and increase plant protein consumption. Without this reduction, the overall goal cannot be achieved. This should involve:

- New strategies and actions on encouraging lower pork and poultry in our diets, and oils as needed
- Public procurement rules to include meat reductions and redesign menus to make more plant-based and lower meat options the default in order to increase uptake, and deliver manageable budgets
- Better labelling rules so that environmental impact as well as other messages eg welfare, is clear on food labels and marketing tools

5. Land use strategy and action reduces animal impact

The government urgently needs to start developing a land use strategy process that will include livestock and feeds and overseas land take, and which will set strong targets to reduce food-feed competition (currently over half of wheat & barley is fed to animals). This should involve:

- A LUS consultation to include suggested action on feeds and livestock land and explicitly consider land use for human-edible cereals fed to animals
- A goal to reduce deforestation and nature destruction in feed and food
- Other areas will be critical including a rethink on the use of land here and overseas for bioenergy crops and biomass.

[220] https://www.wur.nl/nl/onderzoek-resultaten/onderzoeksprojecten-lnv/soorten-onderzoek/kennisonline/renew-multidisciplinair-onderzoek-om-voedselverspilling-bij-food-service-en-retail-te-verminderen.htm scroll down to see publications in English.

6. Farm support via a broad Agriculture Transition Plan) to support no soya systems

Government needs to ensure farm support via financial support (Environmental Land Management Schemes in England), productivity, facilitation, training and skills. This needs to also ensure innovation grants are delivered for the planned phase out of soy use of grains for feed. Elements must include:

- New finance including innovations and capital grants to support farmers changing systems to lower, integrated, forage, fully pastured and stockless systems
- Support for reintroducing legumes (primarily for direct human consumption) into crop rotations given the benefits for soil health, biodiversity
- Support for existing forage, green manures and integrated crop-livestock systems
- Support available for pigs, poultry, systems using co-bi-products and unavoidable food waste. This will include support for rare and traditional breeds with ability to thrive on a wider variety of feed sources
- New free advice and training to support farmers in transition

7. Planning policy and guidance and infrastructure drive production and demand

Planning policy and implementation needs to be fit for purpose, delivering the right guidance to planning authorities to remove unsustainable farm systems and support farmers in transition to new farming practices. This includes:

- A moratorium on new pig and poultry farms that require soy-based beed and support infrastructure needs for new sustainable farm systems
- Tools that ensure local authorities have ability to prohibit new enterprises using soya imports
- Development finance and guidance on delivering the infrastructure needed for processing, new feed production facilities, processing of meat in arable and mixed and small systems (small abattoirs, local cold storage etc)

8. R&D redirected to support the pathway

Major new research, development and innovation funds should support transition via farmer-led and institutional work on alternatives with a new focus on:

- Agroecology rotations using legumes
- Plant breeding programme Genetic Improvement Networks (GINs)
- traditional and native breeds that can use more varied diets
- Training with a new training Institute (The Institute for Agriculture & Horticulture, TIAH) focus on reducing soy and supporting training on alternative approaches
- Insects as feed and feed stocks – ethical and sustainable sourcing
- UK soy research
- Unavoidable food waste as feed
- Incorporating animals into arable systems

Appendices

Appendix 1: Soybean meal content for different species as a proportion of total animal feed

Total UK animal feed production relative to soybean meal content is summarised by species below[221]:

Species	Animal feed production (mT)	Soybean Meal usage (mT)
Cattle (dairy)	3,235,200	235,600
Cattle (beef and calf)	1,179,400	45,500
Pigs	2,112,000	208,700
Poultry (meat)	5,374,860	1,113,800
Poultry (eggs)	1,875,540	209,500
Sheep	858,00	20,600
Equine	173,400	5,200
Fish	352,000	47,200
Other	493,900	51,400
Total	**15,654,300**	1,937500

In addition to this, about 250,000 tonnes of straights or blends are bought by farmers for direct mixing on farm, the rough break-down of which is shown below[222]:

Dairy	125,000t
Beef	25,000t
Pigs	50,000t
Poultry	50,000t
Total home-mix	250,000t

Appendix 2: Soybean meal content of different types of animal feed UK[223]

Diet category	% Soybean Meal
Pig starters and creep feed	19.5
Link/early grower feed	21
Pig growing feed	15.8
Pig finishing feed	5
Pig breeding feed	9.5
Pig protein concentrates	44.5
Chick rearing feed	15.2
Layer feed	11.2
Broiler chicken feed	21.8
Poultry breeding and rearing feed	9.3
Turkey feed	21.8
All other poultry feed	19.3
Poultry protein contents	60

[221] Efeca, supra note 51.

[222] ibid

[223] ibid

Appendix 3: Examples of simple home mixed diets for different stages of pigs (ingredients in kg/tonne)[224]

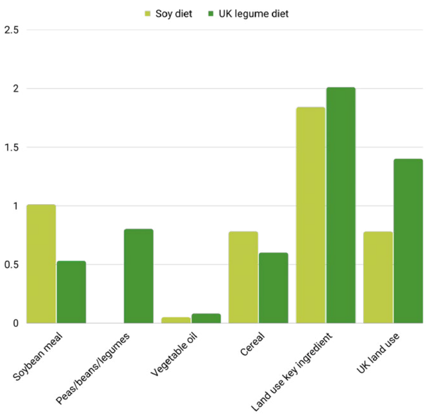
Ingredients (kg/tonne)	Dry sows and boars	Lactating sows	Sucking and newly weaned	Growing pigs	Finishing pigs
Wheat		472	547	475	
Barley	556				456
Wheatfeed	250	200	100	100	250
Peas	150	150	100	150	150
Expeller soy meal (non GMO)				250	125
Full fat soy (non GMO)	20	150	150		
Fishmeal			90		
Calcium carbonate	15	11	10	11	14
Dicalcium phosphate	4	12		9	
Salt	3	3	1	3	3
Vitamin and trace element supplement	2	2	2	2	2

Appendix 4

	Partial replacement						Full replacement			
Study	Nalle 2010		Woyengo 2012		Laudadio 2014		Luadadio 2010		Laudadio 2011	
Alternative legume	Fava varieties		Zero tannin fava		Low-fibre alfalfa		Micronised dehulled peas		Micronised dehulled fava	
Type of poultry	Broilers		Broilers		Laying hens		Broilers		Broilers	
Diet	Control	Beans	Control	Beans	Control	Alfalfa	Control	Peas	Control	Beans
Soybean meal (g/kg feed)	317	226	500	200	150	80	195		195	
Alternative legume (g/kg of feed)		200		500		150		400		310
Meat meal (g/kg of feed)	80	80								
Tallow (g/kg of feed)	10	10								
Wheat (middlings) / Maize (g/kg of feed)	567	448	450	250	705.6	626.7	741.5	538.5	741.5	623.5
Calcium carbonate (g/kg of feed)			16	16	90	86	14	16	14	16
Sunflower or soybean soil (g/kg of feed)	6	15.2			20	26	17	15	17	15
Mono/dicalcium phosphate (g/kg of feed)	10.3	9.9	16	16	17	17.5	13	12	13	12

Appendix 5

Based on the author's own calculations from various sources.[225]



224 Edwards, S. supra note 112

225 https://landworkersalliance.org.uk/wp-content/uploads/2018/10/Soy-No-More-Calculations.xlsx

Appendix 6

The vegetable oil and biofuel link

As discussed above (EU model), if we halt soymeal imports for feed, it would mean that less soy oil would be produced and sold on the global vegetable oil market. If we do not home-produce more vegetable oil, and/or reduce consumption, this will lead to increased demand for palm oil. Palm oil is by far the most efficient oil to produce from a land use perspective, but it contributes to deforestation in highly biodiverse areas mainly in Indonesia, Malaysia and Papua New Guinea.

At the same time, oilseed rape (OSR) production has reduced drastically in the UK. The ban on neonicotinoids has affected growers' ability to deal with flea beetle pests. According to DEFRA production data, OSR yearly cropland from 2010 to 2019 averaged 640 thousand hectares but was only 344 thousand hectares in 2021. Production volumes dropped from a yearly average of 2.2 million tonnes (2010-19) to around 1 million tonnes in 2020 and 2021. One way forward is to grow oilseed in combination with phacelia and buckwheat. It is outside -of-the -scope of this document to explore this issue in detail, but no doubt a major rethink around using vegetable oil as fuel is needed to reduce demand. A further issue is the quantities of oil used in unhealthy processed foods.[226]

Another interlinked issue is that of dried distillers grains with solubles (DDGS) — a by-product of bio-ethanol production – which is an important ingredient in animal feed. The environmental issues related to bio-ethanol production, which in the UK principally uses wheat, sugar beet and maize as feedstock, are beyond the scope of this report.

226 See van Noorden, R. 'Europe prepares to admit that biodiesel is worse than fossil fuels' Nature blog, 27th January 2012: https://blogs.nature.com/news/2012/01/europe-prepares-to-admit-that-biodiesel-is-worse-than-fossil-fuels.html

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