The Vegan Society

One world. Many lives. Our choice.

grow Green

TACKLING CLIMATE CHANGE THROUGH PLANT PROTEIN AGRICULTURE

www.vegansociety.com

Acknowledgments and methodology

This report was produced by The Vegan Society with the input of Dr Amanda Baker, Jasmijn de Boo, Dr Terri Holloway and Jimmy Pierce. We are also grateful to Dr Paul Hill, Bangor University; Nick Saltmarsh, Hodmedod; Jonathan Smith, Transition Scilly; Dr Wendy Russell, University of Edinburgh; Iain Tolhurst, David Graham and Tim Carry, Vegan Organic Network; and Chloe Ward, The Centre for Alternative Technology.

Authors: Andrea Speranza and Dr Lorna Marquès-Brocksopp

Edited by Elena Orde

Designed by Sarah Best and Peter Smith

Illustrations by Adam Duncan

Published by The Vegan Society, September, 2015

Methodology

This research was carried out between May and August 2015 and comprises the following elements:

- Literature review: evidence gathering from key reports and secondary data analysis of statistical databases
- A Freedom of Information request to understand the amount of land in the UK devoted to growing protein crops; the net amount of imported meat (beef and poultry) during 2013-2014 and the countries from where they were imported; the net amount of meat (beef and poultry) exports during 2013-2014 and the countries to which the UK has exported these products
- Several informal interviews with stakeholders who already have experience of growing protein crops and academics currently involved in research in this area.

A note on language

In order to make this report legible we have used commonly-used terms associated with agriculture. However, The Vegan Society wishes to see an end to all animal exploitation, and as non-human animals are sentient beings with their own inherent value, we do not support the use of the terms ‘livestock’, ‘animal products’ or any other description that objectifies non-human animals.

Contents

Foreword

We live in a time of unprecedented social-economic, political and climate change. Policy and decision makers are faced with important questions about developing effective climate action, ensuring food security, addressing public health crises, and listening to increasing concerns about the way animals are treated.

It is time to rethink how we treat each other, the environment and other animals. We should be redirecting resources and efforts away from unsustainable, inefficient, inhumane or exploitative systems, to ways of food provision that show respect for others, and that will still be here for future generations. The subsidy system should be reformed to support growing plant-based sectors, instead of supporting failing animal use industries.

The Vegan Society believes that many of the complex issues politicians face today can be addressed by changing the agricultural system in the UK. This report makes the case to invest in growing 'green'; a better agricultural system that enables current livestock farmers to make a transition to crop farming. There is no better time to act than now, and to sow the seeds of change. Let these be considered and compassionate choices, to create a better society for all.

Jasmijn de Boo
September 2015

Executive Summary and Recommendations

The purpose of this report is to present a promising scenario to our current predicament, with the aim of reducing greenhouse gases (GHGs) – particularly methane and carbon dioxide – generated by the livestock industry. Such a scenario could simultaneously contribute to

- **Reducing the threat to food security**
- **Satisfying many of the nutritional needs of the UK population**
- **Guaranteeing continuity of employment to farmers**
- **Eliminating the unnecessary suffering of millions of animals.**

Given the imperative of making significant GHG reductions over the next 35 years, substituting livestock products with plant protein sources grown in the UK (for human consumption) would be a relatively straight-forward way to address part of a complex problem.

A transition of this type – according to the timescale required – would demand firm political commitment and urgent action in order to halt climate change and meet agreed climate targets. It would also need to be part of a more comprehensive strategy within which the increase of protein crop production was accompanied by incentives to encourage new markets for plant protein products and a public recognition of the benefits they bring.

> There is no doubt in the scientific community that the impacts of livestock production [on climate change] are massive.
>
> *UN Special Rapporteur, Olivier de Schutter (2014:6)*[1]

Nearly a decade ago, the United Nations Food and Agriculture Organization (FAO) published the report Livestock's Long Shadow,[2] which estimated that 18% of annual worldwide greenhouse gas (GHG) emissions were attributable to livestock. This influential text has been widely-cited since as evidence for how livestock production is altering the dynamics of the atmosphere.

Subsequently, the actual global contribution of livestock farming to GHG emissions has been estimated to be at least 14.5%[3] (and possibly as high as 51%[4]) depending on the methodology used to calculate contributions (including land use change and length of time taken into account for GHGs to break down). It is important to note, however, that even 14% is more than emissions from all transport combined.

Nearly ten years on from Livestock's Long Shadow, and a growing body of similar studies call on governments globally to take responsibility for the contribution livestock production is making to climate change. Nearly a decade has passed since we were told that it is not only the planet's ecosystems which are being threatened by this change, but the wellbeing of current and future generations as well.[5] Although we have had over nine years to make changes and act upon the recommendations set out by the FAO, how tangible has our response, as a nation, been? Are we looking to the right places to provide solutions?

A Rationale for Change

- Climate change affects all life on the planet, and as a result, damage to people, the environment and other animals is already a fact of life globally. To avoid dangerous climate change we must limit the average global surface temperature increase to below 2°C. However, it has recently been argued[6] that just 1°C increase has devastating impacts, that we may see an increase of 3-4°C by 2050, while northern latitudes may even see rises of 4-5°C by 2090.[7]
- The global contribution of livestock farming to GHG emissions is agreed to be at least 14.5%, more than all transport combined.
- Farming cattle produces around 65% of livestock farming methane emissions. Livestock farming causes around 44% percent of total human-made methane emissions.[8]
- Methane warms the atmosphere much more strongly than CO_2; however its lifetime in the atmosphere is only about 10 years,[9] versus around 100 years for nitrous oxide and CO_2.[10]
- Reducing livestock numbers, and in particular cattle, would significantly reduce methane emissions.
- The over-consumption of meat in the UK plays a relevant role in increasing GHG emissions. It also threatens food security, particularly in countries where agricultural land is used to grow crops to feed farmed animals.
- Stimulating the production of plant protein sources by encouraging a gradual transition from livestock products would reduce GHGs and the threat to food security. It would also improve the soil and biodiversity in the UK.

- Given the UK has good agricultural and weather conditions for growing plant protein sources, incentivising their production through a transition should be a priority on the political agenda for climate change.

- Encouraging farmers to grow plant protein crops for human consumption would offer them an alternative, more environmentally sustainable, livelihood while also contributing to a strong public health message.

- A plant-based diet provides multiple health benefits, reducing the risks of developing – and in certain cases, enabling better management of – a range of chronic diseases in the UK. Often defined as 'lifestyle-diseases,' obesity, diabetes mellitus, hyperlipidaemia, hypertension, coronary artery disease and cancer have been shown to be decreased among those who consume a consistent plant-based diet.[11]

- Hemp and fava beans are two examples that illustrate the benefits of plant protein sources with regard to the environment, as well as farmers' livelihoods.

Hemp

- Is one of the most sustainable crops
- Can be grown almost anywhere in the UK
- Is a highly efficient CO_2 reducer
- Requires relatively low inputs of fertilizer, herbicides or pesticides
- Needs little water, land and maintenance.

Fava beans

- Add essential nitrogen to soil
- Provide food to beneficial insects
- Are nutritious and environmentally friendly
- Are inexpensive to produce.

- We should incentivise farmers to transition from a livestock system of agriculture to grow protein crops for human consumption. This could be done by providing subsidies for research and development; knowledge transfer; field trials; scaling up of operations; market innovation, and business support for young farmers.

- A transition should be part of a more comprehensive programme in which the manufacturing of plant protein products is supported by incentives aimed at different sectors, thereby opening up new markets during this era of climate change.

- Livestock in the agriculture sector is akin to fossil fuel in the energy sector. This has not yet been fully recognised. Change is needed, urgently.

Conclusion

The livestock sector's impact on climate change has been persistently neglected – in both policy and practice – for almost a decade. Unlike other sectors such as waste, transport and energy in which GHG reductions have been attempted through varying means such as taxes, incentives or subsidies, the livestock sector has enjoyed an unprecedented freedom to carry on with "business as usual".

The reasons for this could include a variety of factors such as pressure from a powerful industry, the globally increasing demand for dairy and meat products, the historical links between consuming meat and social status or inaccurate ideas of what makes 'good' nutrition.

However, the magnitude of the threat of climate change and the importance of reducing GHGs over the next few decades makes the reduction of livestock production in countries such as the UK an essential solution. Supporting a shift toward healthy, accessible alternatives to meat is a key part of this process.

UK residents currently eat an average of around 50% more protein than recommended in a healthy diet.[12] A YouGov poll held in in the UK in 2013[13] found that 25% of respondents said they had reduced their meat consumption over the previous year. The poll also identified a higher percentage of people who said they were willing to consider eating less meat in the future. This trend in the reduction of meat consumption should be stimulated and accompanied by an increase in the production of protein crops for human consumption as substitutes for animal protein (meat, dairy, eggs and fish) products.

The UK climate provides good conditions for growing plant proteins for direct human consumption, such as fava beans, peas, hemp seed or sweet lupin. However, the UK currently assigns only 16% of its agricultural land to growing protein crops, much of which are used to feed farmed animals. Those crops could serve as substitutes for meat and dairy products and provide carbon savings, as well offering many health benefits for the UK population.

A transition away from livestock production – which is currently largely dependent on imported feed crops – to protein crops, ought to be incentivised by providing subsidies for farmers interested in increasing self-resilience. This also would result in a form of agriculture more in line with the planet's ecological carrying capacity.

Encouraging a transition would

- Contribute to the UK GHG reduction targets

- Reduce the threat to global food security by decreasing the UK usage of natural resources in other countries – currently used to grow crops for feeding animals

- Reduce many of the current health issues related to the under-consumption of plant foods, fibre and folate, as well as the over-consumption of protein, and certain specific meat and dairy products

- Encourage farmers to grow plant protein crops for direct human consumption, thus offering them an alternative, positive livelihood, with lower and more stable input costs

- Make the UK an example of best practice for tackling emissions from the livestock sector.

grow Green
Executive summary

Recommendations

The following recommendations would involve a multi-sector approach and the cooperative work of different bodies and governmental departments, including the Department for Environment, Food and Rural Affairs (Defra), the Department of Energy & Climate Change (DECC) and the Department for Business, Innovation & Skills (BIS):

- Government funding should be made available for research into the specific technicalities involved in implementing a transition from a livestock agriculture system to the production of protein plants for human consumption.

- Government funding should be made available for research on the estimated GHG savings that such a transition process could generate in the UK based on different sectors and scenarios. For example, how much GHG could be saved if an average medium-sized farm that produces dairy changes to growing specific protein crops.

- Particular research funding should be allocated to research the potential benefits that a transition process could bring in areas with natural or other specific constraints.

- Considering the comprehensive and multi-sector dimensions involved in transition processes, it is recommended that research and exchange of knowledge about the specific, practical advantages and/or challenges in different regions of the country should be stimulated in the context of local action groups.

- A transition process must be planned as part of a more comprehensive strategy to tackle climate change, whereby the local production of plant protein crops becomes part of a more sustainable and resilient food chain in the UK, thus revitalising rural communities and local economies, and stimulating the consumption of plant protein products.

- The Common Agricultural Policy (CAP) programmes post-2020 should offer schemes and a substantial budget specifically designed to provide support for those farmers interested in transitioning from livestock farming to the production of protein crops for human consumption.

Part I: Why our agricultural system must change

Nearly a decade ago, the United Nations Food and Agriculture Organization (FAO) published the report Livestock's Long Shadow[14] which estimated 18% of annual worldwide greenhouse gas (GHG) emissions were attributable to livestock.

This influential text has been widely-cited since as evidence for how livestock production is altering the mechanisms of the atmosphere. Such changes are either directly through the impact of livestock rearing, or indirectly from the many other processes which eventually result in the marketed animal product.

Elsewhere in the literature, the actual global contribution of 'livestock farming' to GHG emissions has been estimated to be at least 14.5% (some disputed estimates as high as 51%) depending on the methodology used to calculate contributions (including land use change and length of time taken into account for GHGs to break down). It is important to note that even the lower estimate of 14.5% of GHGs caused by livestock is still higher than emissions from all global transport combined.

In this report we refer to the well-established precautionary principle in environmental policy. Scientific uncertainty is not a reason to ignore the knowledge we already have or postpone the action that it appears to demand at a given time.[15]

Although the global livestock sector contributes significantly to emissions attributable to human activity, it is precisely the agricultural sector which can deliver a significant share of the necessary mitigation effort.[16] Indeed, evidence suggests that replacing livestock products with alternatives would be a good strategy for tackling climate change, resulting in fast effects on GHG emissions and their atmospheric concentrations, and thus on the rate the climate is warming.[17]

> Concerted and collective action from all sector stakeholders is urgently required to ensure that existing and promising mitigation strategies are implemented. The need to reduce the sector's emissions and its environmental footprint has indeed become ever more pressing in view of its continuing expansion to ensure food security and feed a growing, richer and more urbanized world population.
>
> *FAO (2013)* [18]

> Total GHG emissions from livestock are positively related to the numbers of livestock. It is likely that our systems will be under political and social pressure to reduce livestock numbers to reduce the levels of emissions.
>
> *Dr. Peter Rowlinson. Proceedings of the International Conference on Livestock and Climate Change (2008)* [19]

Greenhouse gases and livestock

Your average cow will produce around 700 litres of methane per day. This is equivalent to the amount of GHG CO_2 emissions produced by a big 4x4 vehicle travelling around 35 miles per day.

Dr David Davies. Aberystwyth University
Documentary: Meat The Truth 2007

Agricultural-related greenhouse gases and climate change

> It is now widely accepted that concentrations of GHGs in the earth's atmosphere have a direct effect on global temperatures and the energetics of the world's weather systems. Atmospheric CO_2 concentrations have risen by almost 80 ppm (ca.24%) since 1959 and are now increasing at a rate of about 2.5 ppm per year.[20] Land temperatures in the Northern Hemisphere have been rising at a rate exceeding 0.3°C per decade since 1979.[21] If recent trends continue, before the end of the century atmospheric CO_2 concentrations will increase by over 50% and land temperatures in the Northern Hemisphere will rise by over 3°C.[22] The UK average diet embodies emissions equivalent to 8.8kg CO_2 per person per day. [23] Consequently, there is a pressing need to identify mechanisms via which reductions in emissions of GHGs to the atmosphere can be made.

It is estimated that agriculture accounts for about 30% of global GHG emissions and the livestock sector occupies 30% of the world's ice-free land and 70% of all agricultural land.[24] Meat and dairy have the greatest impact, accounting for around half of food-related emissions and about 18% of global greenhouse gas emissions.[25] Dairy production alone accounts for about 4% of global GHG emissions.[26] Food production is estimated to account for almost 20% of UK greenhouse gas emissions.[27]

Carbon dioxide is only one of the GHGs contributing to climate change, and two others are released in large quantities by agriculture. Methane has a GHG potential about 25-fold higher than carbon dioxide i.e., 1 kg methane has a GHG potential of 25kg CO_2 equivalents, and agriculture accounts for about 50% of emissions. Meat and dairy production have high methane emissions and due to the digestive system, release to the atmosphere is particularly significant from ruminants (cows, sheep etc.). Indeed, enteric fermentation can account for up to 75% of the GHGs associated with beef production.

There are also large emissions of methane from animal manure, which can in turn account for 14% of GHG emissions from beef production.[28] Enteric and manure methane emissions are so significant that they account for up to 95% of the GHG emissions from dairy production.[29] Methane emissions from arable agriculture (excepting rice production in flooded soils) are generally negligible[30] and may even be small sinks for methane.

The other principal contributor to agricultural GHG emissions is nitrous oxide (N_2O). This is a powerful GHG with a climate change potential 298 times that of carbon dioxide. Agriculture accounts for about 60% of global anthropogenic nitrous oxide emissions and nitrous oxide emissions account for about 46% of agricultural GHG emissions.[27] Nitrous oxide production from agriculture results mainly from application of nitrogenous fertiliser to soil, spreading of manure and deposition of faeces and urine to pasture by grazing animals.[31] Emissions from arable agriculture can be reduced considerably by efficient application of fertiliser to crops.

This also reduces fertiliser costs, GHG emissions associated with fertiliser production and damage to natural ecosystems and water courses from nitrogen leaching. Nitrous oxide emissions from grazing animals can also be reduced by keeping animals housed, but this tends to increase emissions of gaseous ammonia, which leads to damaging eutrophication and acidification of ecosystems. Indeed, production of meat and dairy is highly inefficient with respect to nitrogen use with only around 7% of nitrogen supplied in feed recovered in the end product.

Dr Paul Hill, Bangor University, Wales.

The world's resources and livestock

> Consumption of agricultural products is responsible for 92% of the water footprint of humanity.
>
> *FAO (2013)*[32]

> Animal agriculture is responsible for up to 91% of Amazon destruction.
>
> *World Bank, 2004*[33]

> Around 75% of the world's agricultural land and 23% of its arable land is used to raise animals, through growing crops for animal feed and through the use of pastures as grazing land.[34] Given the inefficiency of energy transfer in using crops and pasture for meat and dairy production, it would make most sense to grow staple grains and oilseeds for direct human consumption.
>
> *Bailey et. al (2014:13)*[35]

The EU average land consumption per capita (i.e. land used to produce the agricultural and forestry products consumed) is 1.3 hectares, while citizens of countries such as China and India require less than 0.4 hectares per capita. Nearly 60% of the land used to satisfy the demand for agricultural and forestry products in the EU comes from outside Europe.[36] The UK imports products requiring more than 80 million hectares of land a year; this is neither fair nor sustainable.

> A large proportion of crops are used for livestock feed and traded internationally. In developed nations, up to two-thirds of total cereal production is used as animal feed. At a global level, more than a third of all cereals and more than half of all oil crops are used for animal feed. The rise in international feed trade increases inter-regional dependencies, and may increase the vulnerability of many regions to world market-price shocks.
>
> *FAO (2013)*[37]

Industrial livestock systems require more arable land. Cropland for animal feed can increase the demand for high-quality land, resulting in competition with food production or cropland expansion at the expense of grazing lands and forests.

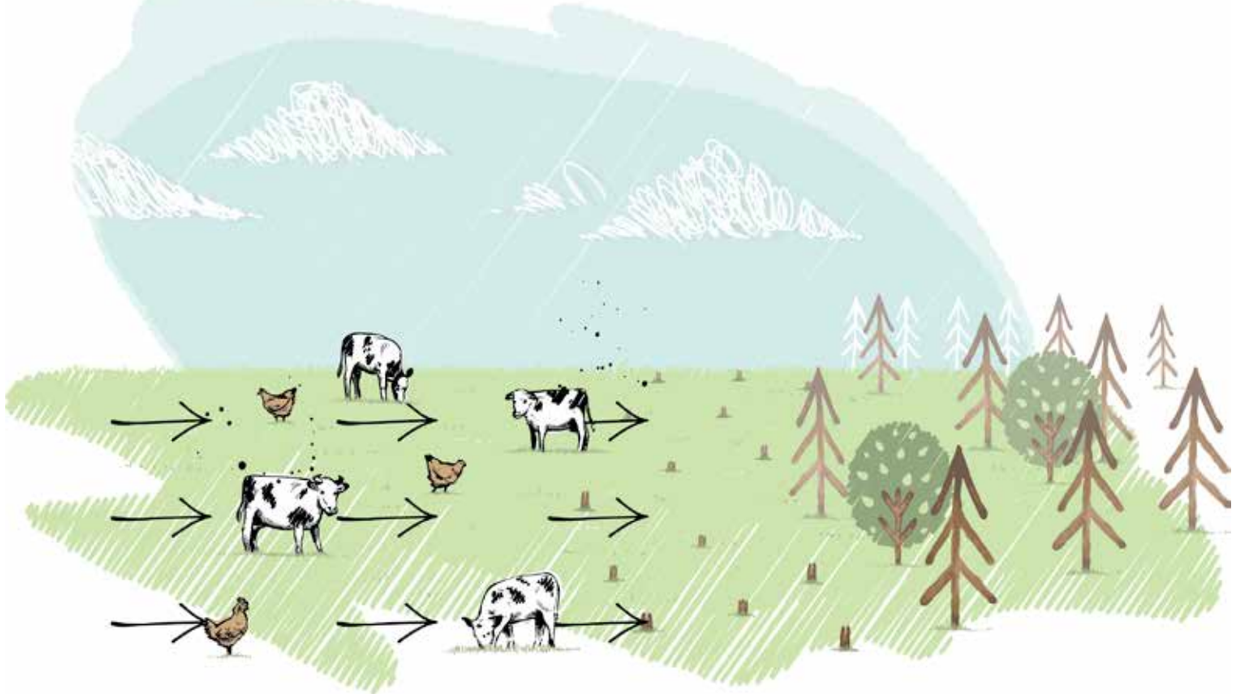
Biodiversity threat

Deforestation overseas is driven by the expansion of pastures and growing crops fed to an estimated 65 billion cows, pigs, chickens and other land[38] animals killed for food and other human uses, each year worldwide.

It is precisely this deforestation which is one of the key reasons for biodiversity threats and species extinctions. A report commissioned by the FAO, USAID and the World Bank (1997) concluded that industrial livestock production contributes to deforestation and species loss through "its demand for concentrate feed, which changes land use and intensifies cropping. The production of feed grains, in particular, adds additional stress on biodiversity through habitat loss and it damages ecosystem functioning".[39]

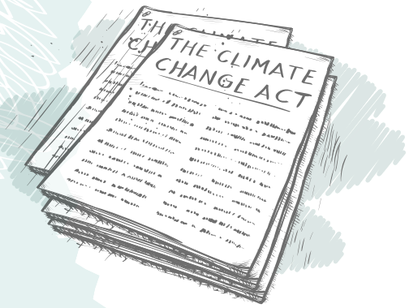
Despite this warning, nearly 20 years later, species are being lost at an unprecedented rate; in June 2015, a report led by the universities of Stanford, Princeton and Berkeley concluded that vertebrates were disappearing at a rate 114 times faster than normal and that the Earth has entered a new period of extinction.[40] The study specifically cites the causes of this as climate change:

> **"The evidence is incontrovertible that recent extinction rates are unprecedented in human history and highly unusual in Earth's history. Our analysis emphasizes that our global society has started to destroy species of other organisms at an accelerating rate, initiating a mass extinction episode unparalleled for 65 million years.**
>
> *Ceballos, Ehrlich, et al (2015)*[41]



Greenhouse gas emissions in the UK food chain

Direct emissions from the UK food system are between 19-20% of the current estimated consumption emissions.[42] Of these, about 58% arise from the production of animal products which account for just over 30% of consumer energy intake. When estimated land use change emissions are considered, food consumption emissions rise to 30% of total consumption emissions.



The UK has a legal commitment to cutting GHGs. Indeed, The Climate Change Act 2008 makes the UK the first country in the world to have a legally-binding, long-term framework to cut GHG emissions by at least 80% on 1990 levels in 2050.[43]

Although the UK emissions inventory is regarded as a leading indicator of progress,[44] the food system presents particular challenges for climate change policy focused on domestic emissions and targets: when land use change emissions are considered, about half of UK food chain emissions arise outside the UK (ibid).[45]

Accountability does not therefore end at our own shoreline. Furthermore, the UK is contributing significantly to global deforestation through its involvement in the global food economy, and crucially, expansion of agriculture is the biggest driver.[45]

UK meat consumption:
Impact on global food security

Global food security for all in 2050 is not feasible with a scenario of livestock intensification and a Western-style diet for all, even with unrealistically high yield scenarios.

Parente & van de Weerd (2012)[46]

The World Food Summit of 1996 defined food security as existing "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life".[47] There is sufficient evidence to show that, with the additional threat of fossil fuel depletion and the urgent need to stop our dependency on it, the further away our food comes from, the higher the risks to food security. Indeed, the UK over-consumption of meat plays a significant role in threatening the food security of those countries where vast areas of agricultural land are used to grow crops to feed animals for a minority of world countries.[48]

> Impacts from agriculture are expected to increase substantially due to population growth increasing consumption of animal products. Unlike fossil fuels, it is difficult to look for alternatives: people have to eat. A substantial reduction of impacts would only be possible with a substantial worldwide diet change, away from animal products.
>
> *United Nations (2010)*[49]

> Global warming is accelerated by unsustainable fossil fuel fed agriculture and ever greater ruminant meat consumption.
>
> *Professor P. James. Past-President World Obesity Federation - London School of Hygiene and Tropical Medicine, UK. EGEA Conference Proceedings. (2015)*[50]

In spite of the numerous initiatives, especially at grassroots level, that advocate for the importance of growing food locally and consuming it seasonally, the UK is still in the irrational situation where, as a nation, it exports nearly everything that it produces and imports almost everything it needs.[51]

In 2014, the UK traded the equivalent of nearly 400 million dead farmed birds. That is to say, the UK imported 423,386 tonnes and exported 352,792 tonnes of 'poultry meat'. With the Netherlands alone, the UK exported 108,046 tonnes and imported 182,100 tonnes in 2014. Approximately 900 million birds are killed each year in the UK for humans to eat.[52, 53]

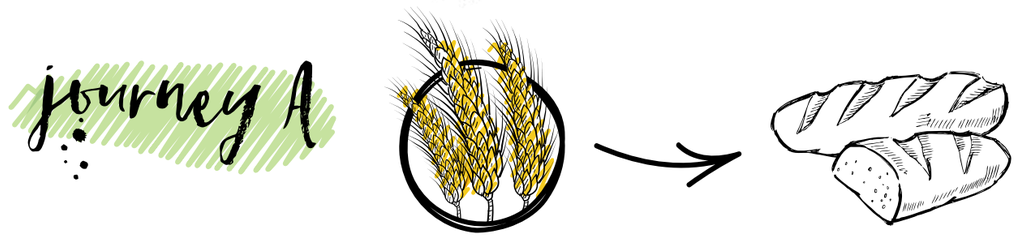
Considering this, it is understandable that approximately one fifth of direct UK food chain emissions in fact occur outside the UK.[54, 55]

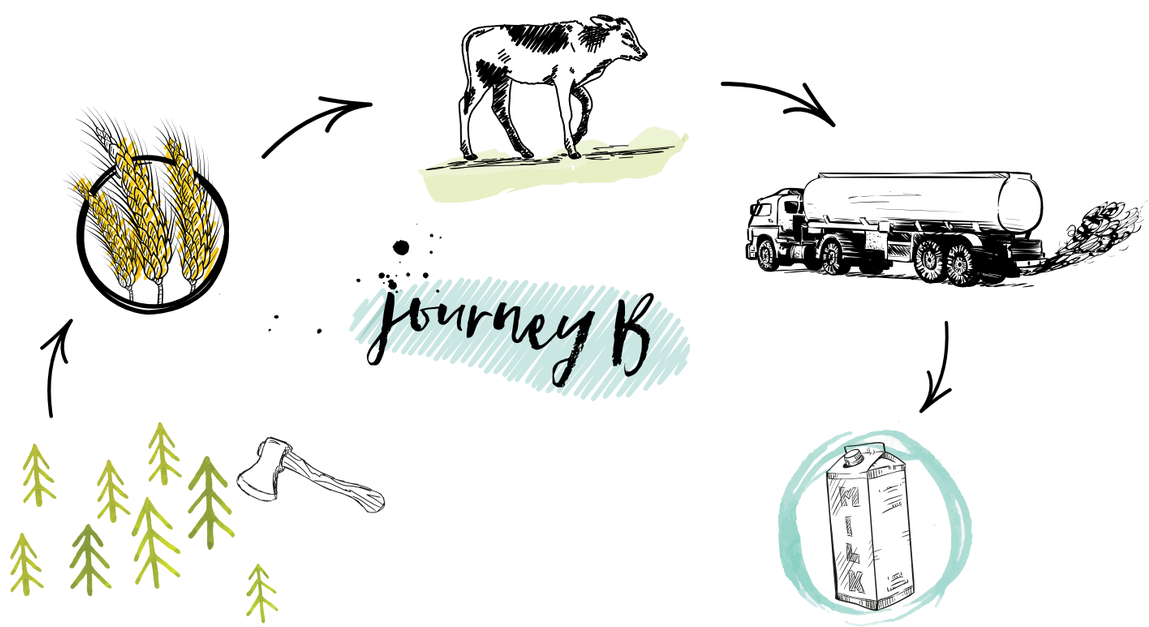
The impact of globalised food systems, to which the UK is a contributor, has triggered a large growth in the international trade of food and feed.[56] Far more agricultural produce is traded today than 30 years ago, and as a result, food security outcomes are connected across space and time. This means that food-price shocks have become a global problem; what happens in one country or region has ripple effects elsewhere.

Why green protein?

Intensive livestock production actually undermines food security since it uses so much of the world's grains – around a third. For simple biological reasons, feeding grain to an animal and then consuming the animal's flesh or milk is always going to be less efficient than consuming the grain directly, whether efficiency is measured in terms of energy (calories), or protein, or land use.

Garnett (2010) [57]





Supporting our farmers

Not only does livestock agriculture play a highly significant part in the rise of GHGs, but those who are affected by climate change are, among many, the very producers of the industry – the farmers:

> **Loss of farms and farmers, and the erosion of localised food networks and regional economies through unemployment are growing issues, largely due to intensification.**
>
> *Škof (2014)*[58]

Thousands of farmers and workers, for example, are forced to leave the industry each year because of the low prices they receive for their produce and the increasing environmental problems associated with climate change.[59] The wellbeing of livestock farmers is being put at risk by the very industry they are trying to maintain – and is arguably reflected in the fact that farmers are one of the professional groups at highest risk of suicide in England and Wales, and account for about 1% of all suicides.[60]

> **...sustainable practices would ... enhance the quality of life for farmers and society as a whole.**
>
> *Škof (2014)* [61]

In effect, livestock farmers are already feeling the negative effects of the very industry they are producing; so much so that Defra (2012:14)[62] have issued recommendations about how key industries, such as agriculture, should be aware of the risks and how they may adapt to such changes in their ways of working: **"It is important that government works with farmers, foresters, land managers and other key organisations to consider the risks ... identify actions to manage risks to the industries ... In agriculture, a shorter crop growth time means that arable farmers and land managers can be more responsive and adaptive to climate change."**

Evidence is therefore mounting to strengthen the view that livestock production and products are a threat not only to the environment, but public health and individual wellbeing, with livestock farmers being particularly vulnerable. More and more studies, organisations and individuals are arriving at the same conclusion, as underlined by UN Special Rapporteur, Olivier de Schutter, whose final report to the UN Human Rights Council insisted on a better link between agriculture, food and health, stressing how, "at the moment these are completely disconnected policies ... We need to focus on wellbeing, not just agricultural production."[63]

These recommendations echo those previously made by the World Health Organisation (WHO) more than 20 years ago. The WHO called on governments to develop policies which support a shift away from livestock production to more sustainable practices so that people can consume crops directly, and thus improve both environmental and human wellbeing:

> **Farming policies that do not require intensive animal production systems would reduce the world demand for cereals ... policies should be geared towards the growing of plant foods and limiting the promotion of meat and dairy.**
>
> *World Health Organisation (1991)* [64]

Almost 20 years later, in 2010, the same recommendations were still being made:

> **In view of the 'inefficiency' of feeding grains to livestock before these livestock are then consumed by humans, UNEP[65] has calculated that the feed grown worldwide for livestock, if released for human consumption, would be sufficient to feed 3.5 billion people.**
>
> *Garnett (2010)*[66]

These recommendations are not new. More than 20 years have passed since the WHO underlined the importance of gearing policies towards growing plant foods and limiting meat and dairy. Decades of scientific investigation have shown the detrimental impact livestock farming has on the environment, public health and global food security.

> **Health as well as climate change analyses reveal the importance of limiting meat consumption economically and changing agricultural policies.**
>
> *Professor P. James. Past-President World Obesity Federation – London School of Hygiene and Tropical Medicine, UK. EGEA Conference Proceedings (2015)*[67]

Given the existing global environmental and health crises, and the looming disasters associated with dangerous climate change, the time to start implementing practical and effective policies is now. One example of a paradigm shift is presented in the following alternative. A scenario which may not only encourage a more self-sufficient and resilient livelihood for farmers and potentially revitalise UK rural communities, but has the potential to significantly reduce GHG emissions associated with livestock farming.

Part II: A better, and greener, way

Agriculture and food for thought

The magnitude of the climate change threat is such that palliative measures and fragmented departmental solutions are no longer an option. We urgently need initiatives that tackle the problem through a comprehensive and multi-sector approach.

Despite the estimate of 19% of GHG emissions being caused by UK food consumption,[68] it should be possible to reduce these emissions by as much as 70% by changing consumption patterns and using improved technology. Indeed, it has been recommended that the UK government should commit to reducing emissions by this amount by 2050.[69]

Although the relationship between climate change and livestock production is both significant and indeed alarming, it is within the agricultural sector that seeds for change can be sown. Indeed, a reduction in methane is in fact much more easily achievable than lower levels of CO_2. Although methane warms the atmosphere much more strongly than CO_2, its lifetime in the atmosphere is only about 10 years, versus at least 100 years for CO_2 and 114 years for nitrous oxide. The starting point, therefore, would be to significantly reduce the number of livestock, which would lead to a dramatic reduction in the emission of methane.

The UK food chain needs to make a proportionate contribution to the UK's 2050 target of reducing its overall emissions by 80%. As underlined, however, in order to achieve this, policy makers will "need to put in place a combination of measures that change not only how we produce and consume food, but also what it is we consume."[70]

As highlighted in the literature,[71] "a significant reduction in livestock raised worldwide would reduce GHGs relatively quickly compared with measures involving renewable energy and energy efficiency."[72] The Fifth Assessment Report of the Intergovernmental Panel on Climate Change showed the global warming potential (GWP) of methane to be 86 times higher than CO_2 in 20 years, and 34 times higher in 100 years. Therefore, reducing methane emissions is even more urgent than carbon emissions, particularly in the next 20-35 years.

As such, if the UK reduced livestock production it would reduce emissions directly through reductions in methane from cattle and waste management, and nitrous oxide from forage and feed production. Indirect reductions would result from reduced nitrogen-related enrichment of habitats, from nitrate leaching and ammonia emissions. Indeed, the most beneficial impact on the environment may be through the indirect effects of livestock on land use change where the production of crops for livestock feed is a driver of deforestation overseas.[73]

However, new initiatives have to be designed without putting livestock farmers in an even more vulnerable situation. Indeed, they may face such vulnerabilities very soon due to oil depletion and the fierce competition for land and water currently used in the majority of the world's countries to grow crops to feed the EU livestock sector.

> In terms of immediacy of action and the feasibility of bringing about reductions in a short period of time, it clearly is the most attractive opportunity.[74]
>
> *Dr. Rajendra Pachauri*
> *Chair of the United Nations*
> *Intergovernmental Panel*
> *on Climate Change*

> The world population currently sits at around 7 billion, expected to rise to between 8 and 10 billion by 2050. To be able to feed everybody, now and in the future, a reduction of livestock and a transition to a more plant-based food pattern is inevitable. Yet far too few political parties have policies in place for tackling this issue.[75]
>
> *Animal Welfare Party,*
> *the UK Political Party for People,*
> *Animals and the Environment*

Green protein as a solution

A 'protein crop' is a plant food which makes a significant contribution to human amino acid needs[76]. A diverse range of crops, both familiar – such as beans (especially fava or broad beans, *Vicia faba*), peas (such as dried and split pea forms of *Pisum sativum*) – and also less familiar – such as hemp (seeding strains of *Cannabis sativa L.*) and sweet lupin (*Lupinus albus*) are viable UK protein crops. Wheat and oats can also supply useful protein, alongside pulses and seeds for essential amino acid balance.[77]

Currently, many people in the UK eat a substantial amount of animal protein. Even so, the UK does not grow enough protein crops to meet the nutritional needs of our human population. At the moment, around one third of UK agricultural land is used for crop farming, or 600,000 hectares.[78] In 2013, the UK grew only about 150,000 hectares of protein crops, and 'produced' about ten times more protein through farming animals for their bodies or their milk.[79] Most of these UK-grown protein crops were fed to farmed animals, either in the UK or elsewhere in the world. Meanwhile, the UK animal farming industry imports large quantities of plant protein – over half of the protein intake of UK cows farmed for their milk comes from feed concentrates, often made from imported pulses.[80]

A transition is needed. The substitution of UK livestock products – currently highly dependent on imported protein crop commodities – for organic plant protein sources grown in the UK, would not only meet many of the nutritional needs of the UK population and open new food markets in an era of climate change, but would also reduce the threat to global food security.

> **... Increasing the production of protein crops would be an important contribution to the sustainable development of European agricultural and food systems ...**
>
> *European Parliament (2013)*[81]

The EU has started to explore the need to increase sustainable protein supply. In 2012, for example, the European Cooperation in Science and Technology (COST) held a workshop[82] which focused on protein sources, and where the workshop participants discussed and identified several research questions and knowledge development areas.

Although a list of such 'actions' (EU-funded projects) has been initiated, most have used a more fundamental scientific approach, rather than focusing on practical implementation of new projects and market innovation. What is needed now, however, is to translate findings and recommendations into field research, in order to significantly invest in a practical plant protein solution during the next few years.

The benefits of plant protein

Stimulating the production of plant protein sources and encouraging a gradual transition from livestock products would not only bring benefits to the planet but also to the soil and UK farmers.

Less fertiliser

The fundamental benefit of growing protein crops for human consumption is the effect of releasing the pressure on land and water in countries that are currently using these resources to feed the UK appetite for meat. Fossil fuels will be saved and demand for fertilisers will be reduced – which further results in lower GHG emissions.

Good for the soil

Grain legumes can be grown as a valuable addition to crop rotations. For example, pulses can provide a 'break' from diseases of the dominant crops, and deter animals which eat the crop. Peas, beans, lupins and other grain legume crops can significantly benefit the next crop, reducing input costs, and also increasing yields.[83] By growing both grain and green manure legumes, there is less need for farms to rely upon animal manures for fertility. This reduces the risks associated with animal manures, such as varying costs and availability, and potential contamination.

Good for farmers and manufacturers

Supporting those farmers who wish to move away from animal farming towards plant protein farming can also improve the wellbeing of individual farmers. Farm business incomes are low and uncertain, particularly for farmers relying on animals, such as in cow's milk.[84] Research has shown that UK farmers and farm workers have relatively high rates of mental health issues.[85] Changing weather patterns, tight economic margins, increasing care cost such as feed and veterinary care, and low farmer confidence are all particularly severe for UK livestock farmers. Plant protein farming can offer a positive alternative livelihood for farmers, with lower and more stable input costs. Increasing consumer interest in value-added food and drink products based on plant protein crops offers a potentially good return on investment. For example, the Dutch 'Vegetarian Butcher'[86] products include meat alternatives made from lupins. These products are not only sold in supermarkets but also traditional butcher shops.

The successful faux meat products were sold in just one shop in late 2010, and were selling in over 180 Netherlands outlets in 2014, with major national and international expansion plans underway. Another innovative Dutch product is the Weedburger[87], a tasty meat alternative made from seaweed that has captured the culinary world's imagination.

Defra (2008)[88] have estimated that UK agricultural land can easily grow sufficient arable crops to meet the basic food needs of the UK population. By increasing the proportion of our protein coming from grain legumes, we can meet our basic food needs from existing UK arable land.

Protecting bees and increasing biodiversity

Protein crops support increased biodiversity including pollinating insects.

By providing nectar and pollen, the mass-flowering of protein crops contributes to the maintenance of bee populations. Additionally, the over-wintering of cereal growth prior to the spring sowing of protein crops stimulates increased populations of birds, small mammals and favourable insects.

Green Protein: Which crops?

grow Green Case study

In this report we illustrate the benefits of plant protein sources by way of two examples: hemp and fava beans.

Hemp

Hemp is one of the most sustainable crops and an excellent CO_2 sequester. The multiple benefits of this plant have been appreciated for centuries in the UK to the extent that policies to encourage this crop extend back to the 16th century when Henry VIII made its cultivation obligatory.

Benefits for the environment

- Sustainable agriculture: hemp replenishes the soil with nitrogen and nutrients, increases the topsoil and restores soil fertility.
- Erosion control: hemp has long roots that firmly hold the soil which help control erosion.
- Carbon sequestration: due to its fast growth, hemp may also be useful in carbon sequestration - absorbing carbon from the air and storing it back into the earth.
- Pollution free: hemp is a hardy plant that can grow almost anywhere in the UK; it hardly needs fertilizer, herbicides or pesticides, so it reduces land, air and water pollution.
- Water-saving: hemp does not need much water to grow, thus reducing demand for water and contributing to tackling the water crisis.
- Land-saving: 1 hectare of usable hemp fibre is equal to the usable fibre of 4 hectares of trees or 2 hectares of cotton. Using hemp could therefore reduce the land used for agriculture.[89]

Benefits for farmers

- A hemp crop is ready to harvest in only 100 days.
- It provides a good break crop, giving the land a rest from other crops and helping to prevent disease.
- Hemp is one of the lowest maintenance crops; it can be grown mostly in any region of the country and on as little as one hectare.
- Farmers do not need special machinery to harvest hemp seed nor fibre.
- Hemp is such a fast growing plant that most weeds cannot penetrate it, providing considerable savings on pesticides and herbicides.

Nutritional benefits

Hemp seeds contain a protein that is nutritious, economical, and potentially more environmentally friendly to produce than meat. Hemp can easily be processed to provide an extensive list of products as alternatives to those derived from the livestock sector, such as

- Milk
- Burgers
- Butter
- Cheese
- Ice cream
- Yoghurt

Hemp protein contains all 20 amino acids used by the human body, including the 9 essential amino acids (EAAs) our bodies cannot produce. Hemp seeds contain an adequate supply of high quality proteins (EAAs) for a well-balanced diet, which helps in reducing the instances of diseases – such as coronary artery disease, hypertension, diabetes, arthritis, osteoporosis, inflammatory and autoimmune disorders and several cancers[90] – as well as helping in excreting toxins from the body. The protein quality of a particular food can be determined by the Protein Digestibility-Corrected Amino Acid Score (PDCAAS), which evaluates protein quality based on both the amino acid requirements of humans and their ability to digest the food.[91] Research shows that a combination of vegetable proteins with adequate energy intake provides enough amino acids of good quality to meet dietary needs.[92]

Hemp possesses excellent nutritional value. It is very rich in essential fatty acids (EFAs)[93] and other polyunsaturated fatty acids.[94] It has almost as much protein as soybean and is also rich in Vitamin E and minerals such as phosphorus, potassium, sodium, magnesium, sulphur, calcium, iron, and zinc.[95, 96]

Approximately 65% of the protein in hemp seeds is made up of the globulin protein edestin[97] and is found only in hemp seed. Edestin aids digestion, is relatively phosphorus-free and is considered the backbone of the cell's DNA.[98]

The other one third of hemp seed protein is albumin, another high quality globulin protein similar to that found in egg white.

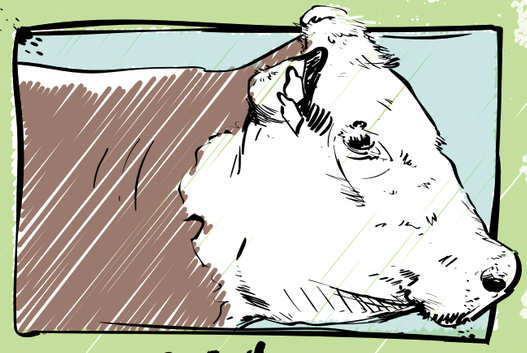
Hemp alternative to milk

Hemp alternative to milk is a vegan product made of a blend of hemp seeds and water. The mixture provides a creamy texture with a delicious taste, which some describe as a 'nutty' flavour. Unlike cow's milk, hemp alternative to milk is easy for the body to digest and does not cause any of the health problems associated with dairy.

Hemp alternative to milk also has several health benefits which include:

- Strengthened immune system
- Clear, healthy skin, hair and nails
- Strong, healthy heart
- Increased mental capacity

One 250ml glass of a typical commercial hemp alternative to milk provides 50% of the omega-3 we need each day. It is low in saturated fat and is fortified with calcium and vitamin D and is also cholesterol-free. Hemp alternative to milk is free from lactose and allergens and is completely safe to consume as the hemp plant does not contain enough tetrahydrocannabinol (the main active ingredient of cannabis) to have any psychoactive effects. It is also much more environmentally friendly than cow's milk as well as a healthy alternative to dairy, and is suitable in tea, coffee and cereal.[99]



Hemp vs Whey

Plant Based	Animal Based
Made from seeds, 100% sustainable	Made from the liquid by-product created in cheese production
High in Omega-3, 6 & 9	**No 'Good' Fats**
Naturally high in Omega-3, hemp protein has all the essential fatty acids the body needs	Whey products contain saturated fat, cholesterol and no essential fatty acids
Non Bloating	**Stomach Cramps/Bloating**
Easy-to-digest protein, gentle for the stomach	Hard to digest, excessive consumption can lead to numerous health problems
Allergen Free	**Allergenic**
Free from dairy, lactose, soya, artificial additives	Unsuitable for those with lactose intolerance, vegan/halal/kosher/ GMO-free diets
Natural	**Refined**
Natural ingredients only	Most products use various artificial additives & sugar

Economic benefits of hemp

The European Union (EU) has an active hemp market, with production in most member nations.[100] In the US, hemp foods sales increased on average by 47% per year between 2005 and 2008 making hemp one of the fastest-growing natural food categories. The Hemp Industries Association estimated the total retail value of North American hemp food, vitamin and body care product sales to be in the range of $113 -129 million US for 2009.[101]

Fava beans

Fava beans are among the oldest crops in the world and like many beans and pulses, are widely grown for human consumption throughout the Mediterranean region and in parts of Latin America.[102]

Fava beans arguably have "yet to be fully exploited in markets where meat is the predominant food source of proteins in the diet. [In the UK] fava bean cultivation could not only make a valuable contribution towards protein self-sufficiency, but could potentially play a role in alleviating the rise of chronic diseases." [103]

Benefits of fava beans include

Environmental benefits

- Diversification of ecosystems on agricultural land, either in time through crop rotation or intercropping. This consequently increases biodiversity
- Providing feed to pollinators and beneficial insects
- Fava beans provide biological nitrogen fixation - taking nitrogen from the atmosphere and stabilising it in the soil. They therefore give assimilated nitrogen not only to the crop, but also to the whole crop rotation
- Reduction of energy demand and GHG emissions after introduction into cereal-rich, intensive crop rotations

Benefits for farmers

- Positive pre-crop results, mainly due to nitrogen effects, but partly also due to non-nitrogen effects
- Mature fava beans can find a premium market through the increasing popularity of European dishes such as hummus-like bean pâtés and dips.

Nutritional benefits

Like hemp seed, fava beans are more nutritious, environmentally friendly, and economical to produce than meat. Fava beans can easily be processed to provide an extensive range of alternatives to livestock products, including pâté, burgers and salads.

grow Green
Case study

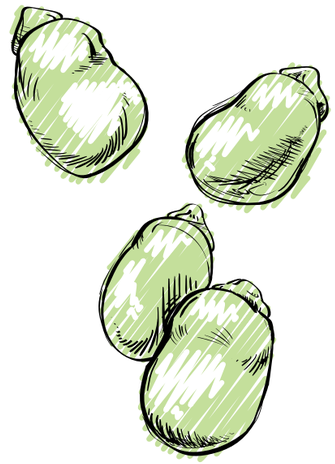
One hundred grams of fava beans contain 7.6 grams of protein, 110 calories and 5.4 grams of dietary fibre. They are rich in beneficial phyto-nutrients such as isoflavone, helping to lower cholesterol levels in the body.

Fava beans contain Levo-dopa, which is a precursor of neuro-chemicals in the brain such as dopamine, epinephrine and nor-epinephrine. Dopamine in the brain is associated with smooth functioning of body movements.

Fresh fava beans are an excellent source of folates. 100g of beans provides 423µg or 106% of the Recommended Dietary Allowance (RDA) of folate. Folate, along with vitamin B_{12} is one of the essential components of DNA synthesis and cell division. Adequate folate in the diet around conception, and during pregnancy may help prevent neural-tube defects in the new born baby.

Fava beans also contain good amounts of vitamin B_6 (pyridoxine), thiamin (vitamin B_1), riboflavin and niacin. These vitamins function as co-enzymes in cellular metabolism of carbohydrate, protein, and fat. In addition, fava beans are one of the finest sources of minerals like iron, copper, manganese, calcium and magnesium. At 1062mg or 23% of daily recommended levels, fava are one of the highest plant sources of potassium. Potassium is an important electrolyte of cell and body fluids. It helps counter pressing effects of sodium on heart and blood pressure.

Research on the nutritional and agronomic properties of fava beans, along with advances in food processing and production, suggest that they will become an important agricultural commodity. Nutritionally, the high fibre and the richness and diversity of bioactive compounds point to fava beans as having a potential role in maintaining human health and disease prevention.



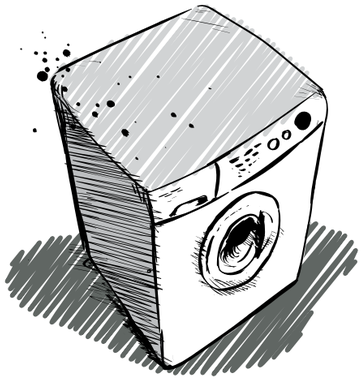
Moving towards a plant-based diet can significantly contribute to a reduction in greenhouse gas emissions [114, 115]

1 day a week

If everyone in the UK abstained from eating meat for one day a week, this would save greenhouse gas emissions equivalent to 13 megatonnes of CO_2 (Mt CO_2eq). This would result in greater carbon savings than taking 5 million cars off the road in the UK (10 Mt CO_2eq).

2 days a week

If everyone in the UK did not eat meat for two days a week, they would save 26 Mt CO_2eq of greenhouse gas emissions. This would save the equivalent of almost 73 million return flights from London to Ibiza.



3 days a week

If all British people abstained from eating meat three days a week, they would save almost 40 Mt CO_2eq of greenhouse gas emissions. This would have the same positive effect on reducing greenhouse gas emissions as replacing all household appliances, such as fridges, freezers, dishwashers and washing machines, with energy efficient ones, insulating walls and installing double-glazing, energy efficient boilers and thermostats (38 Mt CO_2eq).

4 days a week

If all British people ate no meat for four days a week, they would save 52 Mt CO_2eq of greenhouse gas emissions. This would lead to greater carbon savings than taking 20 million cars off the UK roads (all year round). That would be nearly 70% of all cars in the UK. (20 million cars or 42 2 Mt CO_2eq).

5 days a week

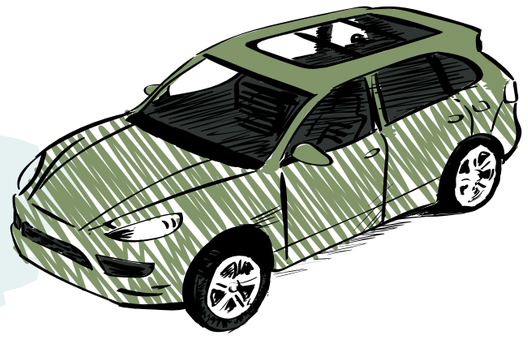
If everyone in the UK abstained from eating meat five days a week, they would save 65 Mt CO2eq of greenhouse gas emissions. This would save more than the emission reductions achieved if the total electricity use of all households in the UK was eliminated (57 Mt CO2eq).

6 days a week

If all British people ate a meat-free diet for six days a week, they would save 78 Mt CO2eq of greenhouse gas emissions. This would create greater carbon savings than removing all the cars off UK roads (73 Mt CO2eq or 29 million cars).

7 days a week

If everyone in the UK abstained from eating meat seven days a week, they would save 91 Mt CO2eq of greenhouse gas emissions. Indeed, this would more than halve the emissions of all greenhouse gasses from the domestic sector (160 Mt CO2eq in 2004). This would be the same as eliminating all greenhouse gas emissions from 12.5 million households in the UK.



A plant-based diet:
Sustainable and healthy

Sustainability

The IPCC Climate Change 2014 report[106] indicates "changing diets towards less GHG-intensive food, e.g., substitution of animal products with plant-based food, while quantitatively and qualitatively maintaining adequate protein content…" as one of the alternatives for reducing GHG emissions from agriculture, forestry and other land-use. Indeed, several studies[107, 108, 109, 110] have compared the environmental impact of various diets and found that well-planned vegan diets have the lowest carbon footprint.

> Based on epidemiological studies, plant-based diets are recommended to prevent against the incidence of chronic diseases. Compared to diets rich in meat and dairy products, plant-based diets are more sustainable, because natural resources are less required and environment is less impacted.
>
> *Amiot-Carlin (2015)*[105]

The case for UK plant protein supply

Currently, much of the protein for milk or dairy substitutes in the EU comes from soya production in the Americas, although this represents a tiny fraction compared to the vast majority of soya produced to feed livestock in Europe and further afield. 70% of European Union livestock protein feed is imported, mostly as soya from the Americas. The feed conversion factor (energy in to energy out) is 3-6 for chickens and pigs, and 14-20 for ruminants.[111] Consequently, even if emissions from transport of soya are taken into account, the GHG emission potential per unit protein is between 2-fold (eggs and poultry) and 12-fold (beef) that from consumption of imported soya protein directly in northern Europe.[112] Although because of inefficiencies in feed to food conversion, actual imports of soya would be unlikely to increase significantly if a meat and dairy free diet was more widely adopted in Europe, emission of GHGs would be reduced further by producing alternatives to meat and dairy locally. This would also increase UK food security.

Currently production of soya is not viable in the UK. Fava beans (*Vicia faba*) have about 25% less protein than soya beans, but grow well in the UK with equivalent GHG emissions per unit protein as soya.[113] As they have a symbiosis with nitrogen-fixing bacteria, they require less nitrogenous fertiliser, which reduces costs to farmers and reduces the GHG emissions from fertiliser production.

Changes to farming practices – for example, more efficient use of fertilisers – can reduce GHG emissions and the carbon footprint. However, losses of energy during the production process mean that animal agriculture is inherently inefficient in comparison to direct consumption of crops by humans.

Dr Paul Hill, Bangor University, Wales.

Public health

In addition to plant-based diets having the potentially lowest level of GHG emissions, they provide multiple health benefits, tackling many of the main 'lifestyle' diseases facing the UK population. If adequately balanced, including a range of lightly-processed grains, vegetables, fruits, and beans, plant-based diets are associated with several health benefits.[116] Chronic diseases significant in the UK, including obesity, diabetes mellitus, hyperlipidaemia, hypertension, coronary artery disease and cancer, have been shown to be decreased among those who consume a consistent plant-based diet (ibid).

An increasing number of studies report adverse effects associated with a diet rich in animal protein, and have generated a greater interest in plant-based diets as a healthier alternative. A number of these studies have specifically linked meat-based diets, which include red and processed meats, with two of the major chronic diseases in the Western World: cardiovascular disease and colon cancer.[117, 118, 119, 120] Furthermore, those who consume meat have been found to have both higher intakes of cholesterol and higher plasma concentrations of total cholesterol and low-density lipoprotein (LDL) cholesterol and triglycerides (TG) than those who consume a plant-based diet.[121] These effects have provoked a worldwide recommendation to limit the consumption of preserved meat, such as sausages, salami, bacon and ham (meaning cured, smoked and nitrate treated meat products), as articulated by the World Health Organisation in 2003.[122] Moreover, in the same report, the WHO recommended adults consume at least 400g of fruit and vegetables a day. Why then, do agricultural subsidies continue to be given to the livestock sector, and the 'wrong' type of crops (such as sugar, maize and oil), when the evidence supports the need to grow more plant protein?

Protein is the major building block of muscle and other body tissues and is used to produce hormones, enzymes, and haemoglobin (the oxygen-carrying pigment of red blood cells). An adequate intake of protein is necessary for growth and repair of body cells, the normal functioning of muscles, transmission of nerve impulses and immunity. Protein can also be used as energy, but is not the body's preferred energy source, so this occurs only when the amount of carbohydrate and fats consumed are insufficient.[123] Consuming a reasonable variety of protein-containing foods such as pulses, nuts, seeds and grains, as part of a diet which includes enough calories overall, will ensure a healthy protein intake.

Plants and Animal-Based Foods
Nutrient Comparison

Per 500 Calories

Nutrient	Plant-Based Foods Mixture*	Animal-Based Foods Mixture**
Cholesterol	0	137
Fat (g)	4	36
Protein (g)	33	34
Beta-carotene (mcg)	29,919	17
Dietary Fibre (g)	31	0
Vitamin C (mg)	293	4
Folate (mcg)	1168	19
Iron (mg)	20	2
Magnesium (mg)	548	51
Calcium (mg)	545	252

* Equal parts tomatoes, spinach, lima beans, peas, potatoes

** Equal parts of beef, pork, chicken,whole milk

Source: The China Study by T. Colin Campbell, PhD

Stock-free farming:
A sustainable future

by **Chloe Ward**, The Centre for Alternative Technology

Plant protein farming for direct human consumption has a lower climate change impact than meat and dairy production. A reduction in animal farming would not only reduce greenhouse gas emissions, but would free up land which could be used for vital biodiversity reserves as well as sequestering carbon to further mitigate climate change.

The majority of UK arable farming is a highly mechanised, large scale practice. Though high yielding, these methods have resulted in a decline in biodiversity and soil health which threaten the resilience of our agro-ecology and therefore our food supply. For example, a lack of diversity of insects and birds can cause an increase in pests, which would previously have been controlled by naturally occurring predators[124]; the use of industrially produced fertilisers rather than bulky composts results in a lower soil organic matter content, causing it to lose its ability to bind together and therefore becoming more prone to erosion by wind or water.[125] In contrast, organic farms manage the land in such a way as to encourage high biodiversity levels and add bulky organic matter to promote soil health.

Providing soil fertility without animal manures

In stock-free organic agriculture, farmers use green manures to provide organic matter and nutrients. Insufficient nitrogen is the factor which most commonly limits plant growth, though crops also require phosphorous, potassium and a range of 'micro-nutrients'. A green manure is a plant which is grown until it provides a thick ground cover, and then ploughed in to the soil. Many green manures are leguminous plants (or legumes) which contain a high amount of nitrogen. This is because legumes form a relationship with nitrogen-fixing bacteria which live in their roots and are able to convert nitrogen gas from the air into a form which can be taken up by plants. The relationship between the plant and the bacteria is one of the famous symbiotic relationships in which both species benefit, with the bacteria gaining sugars fixed by photosynthesis, while the plant gains nitrogen in a usable form.[126]

Not all green manures are nitrogen fixers. Some, for example, Hungarian rye grass, are 'nitrogen lifters' which uptake ready-fixed nitrogen compounds from the soil and hold them in their tissues until they are dug in, thereby preventing nitrogen being lost from the soil by leaching, as well as providing organic matter.[127]

The plentiful nitrogen-rich compounds found in animal manure have originally been produced by the same biological 'fixation' of nitrogen within leguminous plants, which are eaten by animals and concentrated in the animals' tissues and excrement. However, much of the nitrogen will have been lost along the way through leaching of liquids, and emissions of gasses from urine. Therefore, just as the conversion of plant matter into meat loses much of the carbohydrate fixed by photosynthesis, conversion of plant matter into manure can lose a considerable amount of fixed nitrogen.

Farms which fertilise crops purely by green manures have a proportion of their land dedicated to fertility building crops at any one time. This means that the crop productivity

can appear to be lower than that of farms which import nutrients from elsewhere, such as those contained within animal manures or manufactured fertilisers. However, these externally produced inputs also use land and resources in their production, and therefore the real cost of food production is more transparent on farms where fertility is produced on-site.

Green manures can also be sown under and among crops. As well as making good use of space, this increases plant diversity, so making the crops less obvious to pests, and reduces the amount of bare soil exposed to erosion by wind and water. Other plant based soil additions include composts made from municipal garden waste, chipped branch wood, or crop residues such as stubble from cereal crops.

Research to improve stock-free methods

Because of the current reliance on industrially produced fertiliser and animal manure, many stock-free organic techniques are in an early stage of development. A greater understanding of the functioning of soils, plant-microbe relationships and their effect on the cycling of nutrients is vital. Improved soil management techniques could help reduce losses of valuable nutrients by erosion or conversion of nitrogen compounds into the greenhouse gas nitrous oxide.

For example, low-tillage techniques reduce the amount of disturbance to the soil, which can improve soil health by allowing the preservation of soil structure and soil fauna. The use of more perennial crops, such as fruit and nut trees, reduces the need for ploughing, and has the potential to allow more carbon sequestration in the soil.[128]

Another area for improvement is the utilisation of nutrients from waste products. Sewage waste sludge is sometimes added to agricultural land but more research is needed in order to better use this resource without the risk of introducing biological or industrial contaminants.[129] Another under-utilised source of nutrients is that from food waste which can be composted or used in anaerobic digestion which produces energy, as well as nutrient rich digestate.[130]

With agricultural research and on-farm experimentation, there is the potential to increase nutrient use efficiency and therefore crop productivity, as well as reduce greenhouse gas emissions and increase carbon sequestration. We already have the knowledge to increase both the productivity and sustainability of agriculture, by adopting stock-free techniques today. The growing of crops for direct human consumption, coupled with the growing of green manures for direct crop fertilisation, makes stock-free agriculture an efficient and ecologically beneficial system. Supporting and enabling farmers to switch to sustainable stock-free systems would be of huge benefit to the sustainability of UK agriculture.

The Centre for Alternative Technology (CAT) is an education and visitor centre demonstrating practical solutions for sustainability including environmental building, renewable energy and land use. Since 2006, CAT's Zero Carbon Britain team have been researching ways of reaching net zero emissions of greenhouse gases.

CAT does not have an ideological view on veganism, but is advocating a reduction in animal farming in order to reduce our climate impact.

Part III: The next step: Grow Green

Supporting a transition

Agriculture is highly exposed to climate change, as farming activities directly depend on climatic conditions. But, agriculture too contributes to the release of greenhouse gases to the atmosphere. However, agriculture can also help to provide solutions to the overall climate change problem.

The European Commission [131]

With the purpose of reducing the threat of catastrophic climate change and solving other environmental problems, a series of measures have been developed at EU level which have been implemented domestically by the UK government in the last decades. These measures range from making recycling compulsory for residents of certain boroughs, to imposing heavy landfill taxes on local authorities; from subsidies for renewable energy via the Department of Energy and Climate Change, to providing funding to encourage the use of more sustainable modes of transport or growing food locally.

However, there are no corresponding measures when it comes to reducing dependency on livestock - in spite of this being recommended in reports commissioned by the Government itself.[132]

The environmental NGO sector has barely played a role in building political pressure to tackle this problem and in raising awareness amongst their supporters about the negative impact of meat consumption. This trend seems to be slowly reversing with some of the most influential UK campaigning NGOs starting to inform their supporters about the importance of changing one's diet. This will need to be accompanied with the substitution of animal products with more sustainable alternatives such as the plant protein sources presented in this report. Considering that the UK has suitable agricultural and weather conditions to grow protein crops, giving incentives for their production and marketing should be a priority on the political agenda for climate change.

In effect, when it comes to tackling climate change through the energy sector, there is consensus that it is not enough to encourage people to save energy by switching off lights and other electrical devices. We also expect the industry to stop relying on fossil fuels and to move to renewable energy. The same rationale should apply to meat consumption.

We call on the government to develop and adopt a comprehensive and multi-sector approach to invest in plant-based agriculture in order to reduce GHG emissions.

Incentives for stimulating change

Some economic incentives to cap GHG emissions are available on the regulatory world market. One Kyoto protocol mechanism is the Clean Development Mechanism (CDM). Under this scheme, by 2013, only approximately 175 agriculture-related projects had been registered, and very few dealt with methane. Those that did focused on methane avoidance through manure management.[133] In our view, these kinds of projects seem to shift the problem rather than address the root cause.

Several countries in the EU have considered adding a tax on animal foods. Wirsenius et al. (2011[134]) calculated an EU model of food consumption that suggested important GHG mitigation potential. A 7% reduction of current GHG emissions in European Union (EU) agriculture was estimated with a GHG-weighted tax on animal food products of 79 USD_{2010}/tCO_2eq (60 EUR_{2010}/tCO_2eq). Most of the reduction could be achieved by taxing the consumption of ruminant meat alone. Wirsenius et al. (ibid) suggested that the land becoming available through land use changes could be used for bioenergy crops to substitute for coal in power generation. However, we would be interested in seeing a real paradigm shift, where land formerly used for animal farming purposes was diverted to grow protein crops for human consumption.

There is currently a great need to draw up agricultural policies and practices that increase the resilience of the food system in the EU. We need to align production and consumption patterns with the current fragile ecological condition of the planet, in order to face the multiple challenges that scientific studies forecast over the next decades.

A practical intervention, such as providing subsidies for those farmers interested in transitioning from livestock production to organic plant protein sources for human consumption would be an effective incentive. These products are not only more sustainable alternatives to meet the nutritional needs of the UK population, but also guarantee work continuity for farmers.

Can the CAP help?

The Common Agricultural Policy (CAP) is aimed at eliminating over-production and reducing costs. However many of the policies can directly or indirectly alter the price of foods which in turn alters consumer choices and diets. Currently, there are tight EU regulations on dairy produce such as milk and butter in order to maintain EU target prices above the world market. However, this has resulted in a large surplus, such that production exceeds demand by 9%. Policies have been put in place to shift the surplus, yet these policies also generate a potential threat to both public and individual health and wellbeing. For example, the intervention butter scheme enables farmers to sell to the food industry for a reduced price. Being able to sell products cheaply, only because subsidies made it possible to do so, encourages the production of cheaper, high-fat, unhealthy foods such as ice cream, pastries and biscuits.[135, 136] This mechanism also puts pressure on farmers due to the low financial return they receive for their produce. This is unsustainable.

The original 1962 aim of the Common Agricultural Policy (CAP) – one of the oldest policies in the European Union – was to provide price support, improve productivity and stabilise the market.[137] Since it was created, the CAP has been subject to several reforms with the most recent change for the period from 2014 to 2020. For the first time, the commitment to tackle climate change has been established as one of its main objectives.

Indeed, the CAP recognises the negative impact that agriculture has on the climate as well as acknowledging the role that the sector might have in providing solutions. However, it does not seem to recognise the magnitude of the threat that the livestock sector represents. Neither does it seem to be playing any relevant role in providing measures to protect farmers. The CAP should be encouraging a transition to a system of agriculture more aligned with the ecological reality of the planet, and the serious consequences that a deteriorating climate and environment will bring to Europe in the coming decades. [138]

While the CAP is promoting energy crops as an alternative in order to reduce the dependency on fossil fuel, it does not appear to be investing the same resources into reducing the dependency on livestock products - despite the overwhelming evidence underlining their significant contribution to GHG emissions.

The benefits of growing plant protein in Europe have already been highlighted in studies commissioned by the European Union. However to further develop the production and processing of plant protein, collaborative working with different sectors and across the full spectrum of the food supply chain is needed. New markets for products derived from plant protein should be encouraged. New eating habits can be formed that embrace healthy and environmentally-friendly food types. Exploring the viability of this type of initiative under the current CAP framework would accelerate the implementation of plant protein pilot projects.

The CAP is currently divided into two 'pillars'

Pillar 1:

The Single Payment Scheme (SPS)

Pillar 1 concerns market support measures and direct subsidies to EU producers. The SPS gives farmers a single rate payment per hectare of land that they manage or own for maintaining it in a certain condition. Under the programme, the farmer is no longer paid different amounts according to the crop they produce, but a set amount per hectare of agricultural land maintained in cultivatable condition.

Pillar 2:

The Rural Development Programme

Pillar 2 is for rural development programmes and aims to promote economic, social and environmental development in the countryside. In the current period 2014-2020, member states are given more flexibility to choose which measures to implement in order to achieve targets set against six broad "priorities." [139]
While under the current CAP programme the intention to address climate change is present, it does not place the focus on tackling the structural causes of the problem. This could be achieved by encouraging a transition from the livestock sector to arable farming, given the fact that the livestock sector is responsible for 44% of global methane emissions and 65% of agricultural methane, as well as being accountable for significant direct CO_2 emissions plus deforestation indirectly linked to CO_2.

The technicalities of how to implement a transition process are beyond the scope of this report. However, The Legume Futures research[140] funded by the European Union confirmed that public policy intervention to support the increased use of legumes is justified.

Moreover, a study [141] commissioned by the European Parliament's Committee on Agriculture and Rural Development - prior to the last CAP reform - presented six different policy mechanisms within the CAP for supporting plant protein production because of the multiple benefits that this type of crop provides. Two relevant proposals are highlighted here

Voluntary coupled support schemes (direct support under Pillar 1)

The Commission proposal includes provision for voluntary coupled support schemes in order to respond to economic and social challenges in a particular area. These two factors ("economic" and "social" challenges) could be enhanced by an environmental dimension that could allow for the support of legumes. In this case, the EU should provide direct incentives for member states to adopt such coupled support schemes for legumes.

Impact assessment: This option has the potential to allow regional and coupled support schemes to be developed where increasing protein crop production might be particularly beneficial. However, in these areas in particular the subsidy per hectare would need to be quite high to produce the intended effect – typically several hundred Euros per hectare... [142]

Increasing support for organic farming

The use of (protein) crops is a practical necessity in organic farming systems. Additionally, it is intrinsic to the organic farming method to meet many of the environmental issues currently addressed under the CAP programme... [143]

This option also offers the benefits of a promising expanding market. The Soil Association, for example, points out that **"sales of organic products increased by 4% in 2014 to £1.86 billion – remarkable growth in a year when food prices fell by 1.9%, and consumer food spending by 1.1%..."** [144]

Although these two proposed options suggest economic incentives for protein crops, neither of them address the financial aspects of facilitating a transition process. Moreover, both proposals offer the risk that farmers of mixed farming operations might switch from growing other types of crops to protein crops and keep their livestock.

Growing more protein crops outside of a GHG reduction framework arguably undermines the need to substitute protein meat for more climate friendly options and can even contribute to the problem. As the study commissioned by the European Parliament's Committee on Agriculture and Rural Development points out:

"A protein crops policy can be seen as part of a climate protection policy, even though the benefits of protein crops go well beyond the reduction of greenhouse gas emissions and an increase in carbon sequestration in the soil."[145]

Encouraging the growing of more protein crops should address the fundamental reasons why such crops are needed in the first place: as sustainable alternatives to meat protein and dairy. We urge policy makers to also consider the implementation of financial schedules outside the CAP to fully support innovative transition processes that will make Britain take the sustainable lead in Europe.

While the technicalities of this transition process go beyond the scope of this report, anecdotal evidence[146] suggests that – depending on the amount and species of animals, loss of animal manures and other specific factors – a transition process for an individual farm could take between 3-5 years. Realistically, farmers may transition gradually. For example, they may retain some of the livestock whilst beginning to grow protein crops. The Vegan Society, however, would like to see support mechanisms put in place to allow farmers to fully switch to plant protein farming as soon as possible.

Additional considerations should be taken into account regarding promoting the transition process; facilitating information among the sector and establishing an advisory service for those interested in considering the change. Given that young farmers are likely to be the most affected by climate change, it would be sensible to apply a similar approach as the Basic Payment Award[147] for young farmers, who are entitled to a top-up of an additional amount.

From livestock farmer to plant-based protein advocate

Howard F. Lyman is a former fourth-generation family farmer. His forty years' experience as a farmer includes owning a large factory feedlot and raising beef cattle, chickens, pigs, and turkeys among other animals. A health incident led him to reflect critically about the livestock sector and to become an advocate of organic plant-based farming and vegan diets.

> **The question we must ask ourselves as a culture is whether we want to embrace the change that must come, or resist it. Are we so attached to the dietary fallacies with which we were raised, so afraid to counter the arbitrary laws of eating taught to us in childhood by our misinformed parents, that we cannot alter the course they set us on, even if it leads to our own ruin? Does the prospect of standing apart or encountering ridicule scare us even from saving ourselves?**[148]

Beneficial to all

The rationale for change is clear; the solutions lie before us. What is needed is the political will to transform an agricultural system and invest in a better future for all; farmer willingness to begin a transition; field research to help facilitate transition processes, and protein crop data to encourage stakeholders. The University of Aberdeen[149] is currently undertaking a comprehensive study which involves the identification of plant protein sources that could be produced in Scotland, such as lupin, hemp, buckwheat, pea and fava bean, and establishing their nutritional attributes.

The study also aims to identify barriers to incorporating more plant-based protein sources within the agri-food supply chain and by consumers, and to create an information platform to assist the Scottish Food industry to respond to change.

In a workshop held as part of the study to identify some of the barriers and opportunities perceived by farmers around growing protein crops, the need for creating a new market and encouraging demand for these sustainable plant protein alternatives were highlighted.

Plant protein and the local economy

> **Reducing animal-based product consumption is realistic if we can offer delicious, convenient, plant-based foods that people want to eat.**
>
> *Dr. Brian Machovina, Florida International University.*[150]

There are already good examples of innovative UK food businesses providing attractive forms of plant protein production that are working successfully with local farmers.

Hodmedod

> **... Demand for these products is strong and growing rapidly ...**
>
> *Nick Saltmarsh, founder of Hodmedod*

Hodmedod was founded in 2012 following research into the scope for production and supply of plant protein in the UK. While the main British protein crop, fava beans, is almost entirely exported, the vast majority of dried and canned pulses on British shop shelves are imported.

The founders of Hodmedod (Nick Saltmarsh, Josiah Meldrum and William Hudson) ran a trial project through the summer of 2012 to see if people in Norwich would enjoy eating fava beans from East Anglia – they did.

Hodmedod was founded to continue and develop this supply of fava beans to the British market, while working to source and develop production of more British-grown plant proteins.

Hodmedod now supplies both conventional and organic fava beans alongside a range of dried peas, a growing selection of phaseolus beans and quinoa.

As well as dried pulses and quinoa, Hodmedod is developing a range of canned pulse products, pulse and quinoa flours, and roasted snack beans and peas, in order to extend the uses and consumption of these British-grown protein-rich foods.

Hodmedod supplies its production nationally, from online sales to individual customers, through direct supplies to retailers and caterers, to indirect supplies through national fine food and wholefood distributors.

Hodmedod has grown over the last three years to work with over 20 farmers and is now sourcing over 100 tonnes of pulses and quinoa annually for supply to retailers, caterers and manufacturers across the UK.

With growing popular concern about the provenance of food and the environmental impact of meat production, the time is ripe for a rediscovery and renaissance of British-grown pulses. Hodmedod is meeting this latent demand by bringing British pulses to UK retail and catering markets: reintroducing varieties that have fallen out of use completely, promoting pulses still eaten in limited ways for use in a wider range of recipes and working with growers to trial varieties not in commercial production. Dried fava beans from farms in East Anglia are not just a sustainable local source of plant protein but also a delicious and healthy ingredient and a largely forgotten part of British food culture.

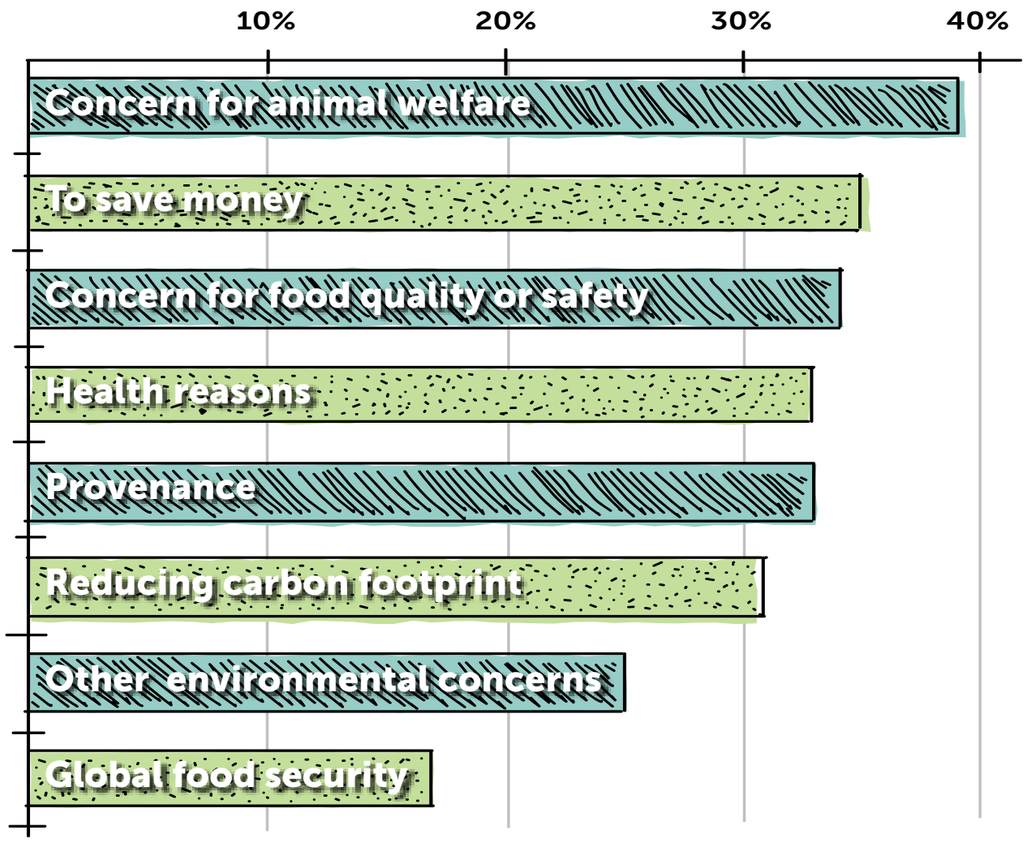
Good Hemp

Good Hemp is a UK company that produces healthy food products from hemp sources directly from its farm in North Devon. It provides a variety of products such as hemp milk, hemp oil and hemp seed, offering a more environmentally friendly and healthy option than animal protein and dairy products.

A growing trend: Reducing meat

In 2013, a YouGov poll found that 25% of respondents said they had reduced their meat consumption over the previous year. They also found a higher percentage of people (34%) saying they were willing to consider eating less meat in the future, compared to those who were not willing (30%). As this illustration shows, there were many different reasons for wishing to reduce meat intake. This figure was maintained in 2014 (35%), indicating considerable interest among a large section of the population.

The Vegan Society welcomes this trend. However, the society's vision remains a world in which humans do not exploit any other animals. The educational charity promotes a diet and lifestyle, which seeks to exclude – as far as is possible and practicable – all forms of exploitation of, and cruelty to, animals for food, clothing or any other purpose; and by extension, promotes the development and use of animal-free alternatives for the benefit of humans, animals and the environment.



Adapted from www.eating-better.org/uploads/Documents/Let'sTalkAboutMeat.pdf

Conclusion

The livestock sector's impact on climate change has been virtually ignored for almost a decade. Unlike other sectors such as waste, transport, and energy from which GHG reductions have been attempted through varying means such as taxes, incentives or subsidies, the livestock sector has enjoyed an unprecedented freedom to carry on with "business as usual".

The reasons for this could include a variety of factors such as pressure from a powerful industry, the globally increasing demand for dairy and meat products, the historical links between consuming meat and social status or the idea of what makes 'good' nutrition.

However, the magnitude of the threat of climate change and the importance of reducing GHGs over the next few decades makes the reduction of meat production in countries such as the UK an essential solution.

Love your green protein

Love Food Hate Waste[151] was a successful national campaign implemented at a local level by local authorities across the country. A variety of attractive campaign materials – ranging from recipes showing how to prepare meals using leftovers, to tips on how to prevent food waste – were designed and made available for free to members of the public. The political will to raise awareness of a problematic topic such as excessive food waste, and the ability to do it appropriately, showed positive results: food waste has been cut by an impressive 21% since 2007, saving UK consumers almost £13 billion over the five years to 2012.

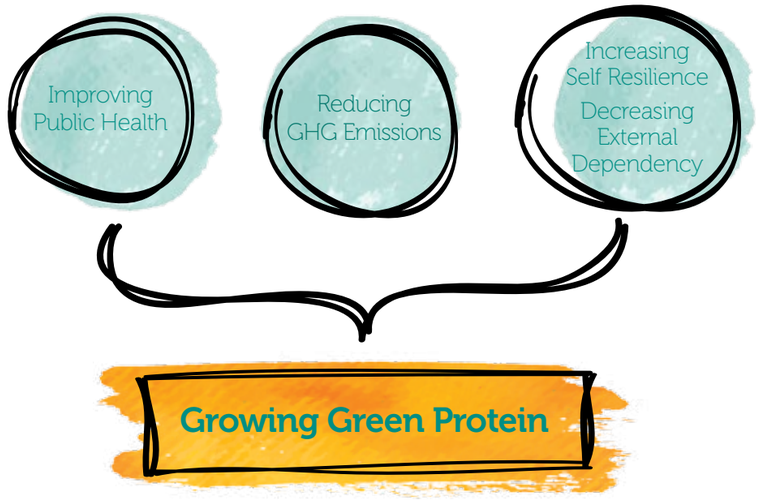
This campaign has set a precedent of a government initiative that encouraged people to eat a certain type of thing: their leftovers. Considering the multiple benefits of plant-based sources of food, when will policy makers develop a similar initiative that encourages us to consume more green protein?

The trend in the reduction of meat consumption should be stimulated and accompanied by an increase in the production of protein crops for human consumption as substitutes for animal protein (meat, dairy, eggs and fish) products.

The UK climate provides perfect conditions for growing plant proteins such as

fava beans, peas, hemp or sweet lupin. However, the UK currently assigns only 16% of its agricultural land to growing protein crops. Those crops could serve as substitutes for meat and dairy products, providing carbon savings as well many other health benefits for the UK population.

A transition away from livestock production – which is currently largely dependent on imported feed crops – to organic protein crops, ought to be incentivised by providing subsidies for farmers interested in increasing self-resilience, which also results in a form of agriculture more in line with the planet's ecological carrying capacity .



Encouraging a transition would

- Contribute to the UK GHG reduction targets
- Reduce the threat to global food security by decreasing the UK usage of natural resources in other countries – currently used to grow crops for feeding animals in Europe
- Reduce many of the current health issues related to the over-consumption of certain meat and dairy products
- Encourage farmers to grow plant protein crops for direct human consumption thus offering them an alternative, positive livelihood, with lower and more stable input costs
- Make the UK an example of best practice for tackling emissions from the livestock sector.

Recommendations

The following recommendations would involve a multi-sector approach and the cooperative work of different bodies and governmental departments, including the Department for Environment, Food and Rural Affairs (Defra), the Department of Energy & Climate Change (DECC) and the Department for Business, Innovation & Skills (BIS).

- Government funding should be made available for research into the specific technicalities involved in implementing a transition from a livestock agriculture system to the production of protein plants for human consumption.
- Government funding should be made available for research on the estimated GHG savings that such a transition process could generate in the UK based on different sectors and scenarios. For example, how much GHG could be saved if an average medium-sized farm that produces dairy changes to growing specific protein crops?
- Particular research funding should be allocated to research the potential benefits that a transition process could bring in areas with natural or other specific constraints.
- Considering the comprehensive and multi-sector dimensions involved in transition processes, it is recommended that research and exchange of knowledge about the specific, practical advantages and/or challenges in different regions of the country should be stimulated in the context of local action groups.
- A transition process must be planned as part of a more comprehensive strategy to tackle climate change, whereby the local production of plant protein crops becomes part of a more sustainable and resilient food chain in the UK, thus revitalising rural communities and local economies, and stimulating the consumption of plant protein products.
- The CAP programmes post-2020 should offer schemes and a substantial budget specifically designed to provide support for those farmers interested in transitioning from livestock farming to the production of protein crops for human consumption.

References

1 http://www.ohchr.org/EN/HRBodies/HRC/RegularSessions/Session25/Documents/A_HRC_25_57_ENG.DOC (accessed 14/08/2015)

2 Food and Agriculture Organization of the United Nations (FAO) Livestock's Long Shadow: environmental issues and options. Rome, Italy: FAO; 2006 ftp://ftp.fao.org/docrep/fao/010/a0701e/a0701e00.pdf (accessed 11 August 2015)

3 Food and Agriculture Organization of the United Nations (FAO) Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. Rome, Italy: FAO; 2013.

4 Goodland, R & Anhang, J Livestock and Climate Change: Report for World Watch. New York: 2009

5 Food and Agriculture Organization of the United Nations (FAO). 2013, ibid

6 Anderson, K & Bowes, A. Beyond 'dangerous' climate change: emission scenarios for a new world. Phil. Trans. R. Soc. A. 2011; 369: 20-44. http://rsta.royalsocietypublishing.org/content/369/1934/20.full (accessed 10 Aug 2015)

7 Costello, A., Abbas, M et al. Managing the health effects of climate change. Lancet 2009; 373: 1693–733.

8 Food and Agriculture Organization of the United Nations (FAO) 2013, ibid

9 The Intergovernmental Panel on Climate Change (IPCC) Climate Change 2013. The Physical Science Basis. Frequently Asked Questions. IPCC; 2013. http://www.ipcc.ch/organization/organization.shtml (accessed 14/08/2015)

10 The IPCC (2013: ibid) note that "...about 15 to 40% of the CO2 pulse is still in the atmosphere after 1000 years."

11 Craig, WJ & Mangels, AR Position of the American Dietetic Association: vegetarian diets. J Am Diet Assoc 2009; 109(7): 1266-1282

12 From the FAO Statistics site http://faostat3.fao.org/

13 http://www.eating-better.org/uploads/Documents/Briefing_Eating_Better_YouGov_survey.doc (accessed 04/08/2015)

14 Food and Agriculture Organization of the United Nations (FAO), 2006, ibid

15 Hill AB The environment and disease: association or causation? Proc R Soc Med. 1965; 58: 295–300.

16 Food and Agriculture Organization of the United Nations (FAO), 2013, ibid.

17 Goodland, R & Anhang, J, 2009, ibid.

18 Food and Agriculture Organization of the United Nations (FAO), 2013, ibid.

19 Dr. Peter Rowlinson. Proceedings of the International Conference on Livestock and Climate Change, Tunisia, 17-20 May, 2008

20 Tans, P. & Keeling, R. Trends in Atmospheric Carbon Dioxide. National Oceanic and Atmospheric Administration Earth System Research Laboratory Global Monitoring Division,Scripps Institute of Oceanography; 2014.

21 The Intergovernmental Panel on Climate Change (IPCC). Climate Change 2007: The Physical Science Basis. Cambridge: Cambridge University Press; 2007.

22 Tans & Keeling, 2014, ibid.

23 Hoolohan C, Berners-Lee M et al. Mitigating the greenhouse gas emissions embodied in food through realistic consumer choices. Energy Policy 2013; 63: 1065-1074.

24 Temme EH, van der Voet H et al. Replacement of meat and dairy by plant-derived foods: estimated effects on land use, iron and SFA intakes in young Dutch adult females. Pub Health Nutr 2013;16: 1900-1907

25 Garnett, T Livestock-related greenhouse gas emissions: impacts and options for policy makers. Environmental Science and Policy 2009; 12: 491 – 503

26 Henriksson M, Flysjö A et al. Variation in carbon footprint of milk due to management differences between Swedish dairy farms. Animal 2011; 1–11

27 Smith, P., Martino, D. et al. Agriculture. Chapter 8 of The Intergovernmental Panel on Climate Change (IPCC), 2007, ibid.

28 D. Nijdam, T. Rood, H. et al. The price of protein: review of land use and carbon footprints from life cycle assessments of animal food products and their substitutes Food Policy 2012; 37: 60–77

29 Hagemann, M., Hemme, T., et al. Benchmarking of greenhouse gas emissions of bovine milk production systems for 38 countries. Anim. Feed Sci. Technol 2011; 166–167:46–58.

30 Carlsson-Kanyama, A., González, A.D. Potential contributions of food consumption patterns to climate change. American Journal of Clinical Nutrition 2009; 89 (5): 1704S–1709S.

31 del Prado, A., Chadwick, D. et al. Exploring systems responses to mitigation of GHG in UK dairy farms. Agric. Ecosyst. Environ. 2010; 136: 318–332.

32 FAO (2013): www.fao.org/docrep/018/i3347e/i3347e.pdf (accessed 03/07/2015)

33 https://openknowledge.worldbank.org/handle/10986/15060 (accessed 03/07/2015)

34 Foley, JA, Ramankutty, N et al. Solutions for a Cultivated Planet Nature 2011; 478: 337–42.

35 Bailey R, Froggatt, A et al. Livestock – Climate Change's Forgotten Sector. Chatham House; 2014.

36 Lugschitz, B., Bruckner, M. et al. Europe's global land demand. A study on the actual land embodied in European imports and exports of agricultural and forestry products. Vienna: Sustainable Europe Research Institute; 2011.

37 Food and Agriculture Organization of the United Nations (FAO) Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. Rome, Italy: FAO; 2013.

38 No reliable figures exist for the numbers of sea animals killed. Farmed fish feed includes crops, free-caught fish and farmed animal parts.

39 http://www.fao.org/docrep/x5303e/x5303e0c.htm (accessed 20/06/2015)

40 http://advances.sciencemag.org/content/1/5/e1400253.full (accessed 20/06/2015)

41 Ceballos, G Ehrlich PR et al Accelerated modern human–induced species losses: Entering the sixth mass extinction Science Advances 2015; 1, 5: e1400253

42 Audsley E, Brander, M et al. How low can we go? An assessment of greenhouse gas emissions from the UK food system and the scope for to reduction them by 2050. Report for the WWF and Food Climate Research Network WWF-UK; 2009.

43 https://www.theccc.org.uk/tackling-climate-change/the-legal-landscape/global-action-on-climate-change/ (accessed 04/08/2015)

44 Audsley E, Brander, M et al, 2009, ibid.

45 This analysis is based on the proportion of global land use attributable to the supply chain on the basis of average global yields. Since managed and native grassland covers more land than arable crops, this analysis attributes a large proportion (c.a three quarters) of LUC emissions to ruminant meat (Audsley E, Brander, M et al. 2009, ibid: 66)

46 Parente, S & van de Weerd, H Food Security & Farm Animal Welfare. Report for WSPA and CIWF. London; 2012. http://www.ciwf.org.uk/research/food/food-security-and-farm-animal-welfare/ (accessed 15/08/2015)

47 http://www.who.int/trade/glossary/story028/en/ (accessed 20/06/2015)

48 https://www.ciwf.org.uk/media/3817742/global-benefits-of-eating-less-meat.pdf (accessed 04/08/2016)

49 United Nations Environment Programme (UNEP) Assessing the Environmental Impacts of Consumption and Production: Priority Products and Materials. A Report of the Working Group on the Environmental Impacts of Products and Materials to the International Panel for Sustainable Resource Management. Nairobi, Kenya: UNEP; 2010:82.

50 Professor P. James. Past-President World Obesity Federation - London School of Hygiene and Tropical Medicine, UK. EGEA Conference Proceedings, May, 2015. http://www.egeaconference.com/en/127/programme/ (accessed 14/08/2015)

51 Robinson, D. In the light of the need for greater self-sufficiency through the predicted impacts of CC and PPO, could Powys become self-reliant in food by 2020? MSc thesis 2010; University of East London.

52 https://www.gov.uk/government/collections/overseas-trade (accessed 22/07/2015)

53 https://www.gov.uk/government/statistics/poultry-and-poultry-meat-statistics (accessed 22/05/15)

54 Audsley E, Brander, M et al. 2009, ibid: 66

55 Garnett T. Cooking Up A Storm. Food, Greenhouse Gas Emissions and Our Changing Climate. Surrey, UK: Centre for Environmental Strategy, University of Surrey; 2008.

56 Robinson, D (2010): ibid

57 Garnett, T. Livestock, feed and food security. FCRN Briefing Paper. January 2010.

58 Škof, N Beyond choices: Critical reflections on the (re)production of food-related discourses and actions. Thesis. 2014.

59 www.ukfg.org.uk/UK_CAP_casestudy.pdf (accessed 16/06/2015)

60 http://www.fwi.co.uk/farm-life/suicide-investigating-a-farming-taboo.htm (accessed 08/06/2015)

61 Škof, N 2014, ibid

62 Department for Environment Food & Rural Affairs (Defra) The UK Climate Change Risk Assessment (CCRA) Government Report. London: Defra; 2012.

63 http://www.srfood.org/en/final-report-to-un-human-rights-council (accessed 19/06/2015)

64 World Health Organisation (WHO) Diet, Nutrition and the Prevention of Chronic Diseases. Technical Report Series 797. Geneva, Switzerland: WHO; 1991.

65 United Nations Environment Programme (UNEP) The Environmental food crisis: The environment's role in averting future food crises. Nairobi, Kenya: UNEP; 2009.

66 Garnett, T. 2010: ibid: 2

67 James, P. EGEA Conference Proceedings, May,2015 .http://www.egeaconference.com/en/127/programme/ (accessed 14/08/2015).

68 Audsley E, Brander, M et al., 2009, ibid.

69 Garnett T, 2008, ibid.

70 Audsley E, Brander, M et al., 2009, ibid.

71 Goodland, R & Anhang, J, 2009, ibid: 13.

72 The capacity of greenhouse gases to trap heat in the atmosphere is described in terms of their global

warming potential (GWP), which compares their warming potency to that of CO2 (with a GWP set at 1). The new widely accepted figure for the GWP of methane is 25 using a 100-year timeframe - but it is 72 using a 20-year timeframe, which is more appropriate because of both the large effect that methane reductions can have within 20 years and the serious climate disruption expected within 20 years if no significant reduction of GHGs is achieved. The Intergovernmental Panel on Climate Change supports using a 20-year timeframe for methane. (Goodland & Anhang, 2009: 13-4).

73 Audsley E, Brander, M et al., 2009, ibid.

74 Dr. Rajendra Pachauri. Chair of the United Nations Intergovernmental Panel on Climate Change. Lecture: 'Global Warning - The impact of meat production and consumption on climate change'. September 2008

75 http://www.animalwelfareparty.org/wordpress/wp-content/uploads/2014/05/Animal-Welfare-Party-2014-EU-Parliament-Manifesto-We-Think-Its-Time-To-Make-History.pdf (accessed 17/06/2015) DISCLAIMER: The Vegan Society does not support any political parties or candidates. However, we are able to highlight any particular policies which are in alignment with The Vegan Society vision.

76 http://www.who.int/nutrition/publications/nutrientrequirements/WHO_TRS_935/en/ (accessed 26/08/2015)

77 http://www.who.int/nutrition/publications/nutrientrequirements/WHO_TRS_935/en/ (accessed 16/07/2015)

78 https://www.cia.gov/library/publications/the-world-factbook/geos/uk.html (accessed 15/07/2015)

79 http://www.ukagriculture.com/crops/peas_uk.cfm (accessed 15/07/2015)

80 http://www.fcrn.org.uk/sites/default/files/TGlivestock_env_sci_pol_paper.pdf (accessed 26/08/2015)

81 European Parliament's Committee on Agriculture and Rural Development. Environmental Role of Protein Crops in the New Common Agriculture Policy. Brussels: European Parliament; 2013. http://www.legumefutures.de/images/The_environmental_role_of_protein_crops_in_the_new_Common_Agricultural_Policy.pdf (accessed 07/08/2015)

82 http://www.cost.eu/events/protein(accessed 15/08/2015)

83 http://www.sciencedirect.com/science/article/pii/S0378429015000301 (accessed 04/08/2015)

84 UK Dairy Farm Business Income figures to 2014: http://dairy.ahdb.org.uk/market-information/farming-data/dairy-farm-incomes/farm-business-income/#.VcIdkPm6fmF (accessed 04/08/2015)

85 http://www.andrewmayers.info/rural-mental-health-research.html (accessed 04/08/2015)

86 http://www.vegetarianbutcher.com/ (accessed 15/08/2015)

87 http://dutchweedburger.com/en/ (accessed 15/08/2015)

88 http://www.ifr.ac.uk/waste/Reports/DEFRA-Ensuring-UK-Food-Security-in-a-changing-world-170708.pdf (accessed 04/08/2015)

89 http://1st-ecofriendlyplanet.com/tag/environmental-benefits-of-hemp/ (accessed 27/07/2015)

90 Simopoulos AP The importance of the omega-6/omega-3 fatty acid ratio in cardiovascular disease and other chronic diseases. Exp Biol Med (Maywood) 2008; 233:674-88.

91 Marsh, K, Munn, E et al. Protein and vegetarian diets. Med J Australia 2012;1, 7-10.

92 Craig, WJ & Mangels, AR. 2009, ibid.

93 Lesma, G, Consonni, R et al. Cannabinoid-free *Cannabis sativa L*. grown in the Po valley: evaluation of fatty acid profile, antioxidant capacity and metabolic content. Nad Prod Res. 2014; 28(21): 1801-7.

94 Industrial Hemp. Agriculture and Agrifood Canada. Government of Canada. http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-product-sector/crops/pulses-and-special-crops-canadian-industry/industrial-hemp/?id=1174595656066 (Accessed 4/08/2015).

95 Callaway JC Hempseed as a nutritional resource: An overview. Euphytica 2004;140:65-72.

96 http:// http://www.finola.fi/ (Accessed 16/07/2015)

97 Docimo T, Caruso, I et al. Molecular characterization of edestin gene family in *Cannabis sativa L*. Plant Physiol Biochem 2014;84:142-8.

98 Tang CH, Zen, Z et al. Physicochemical and functional properties of hemp (*Cannabis sativa L.*) protein isolate. J Agric Food Chem 2006; 54(23):8945-50

99 Callaway, JC, 2004: ibid

100 For further information about hemp as an agricultural commodity see: https://www.fas.org/sgp/crs/misc/RL32725.pdf (accessed 14/08/2015)

101 http://thehia.org/HIAhemppressreleases/3346472 (accessed 18/08/2015)

102 United Nations University archive http://archive.unu.edu/unupress/food/8F083e/8F083E03.htm (accessed 14/08/2015)

103 http://onlinelibrary.wiley.com/doi/10.1111/1541-4337.12146/full (accessed 14/07/2015)

104 http://www.researchgate.net/profile/Ulrich_Koepke/publication/222158321_Ecological_services_of_faba_bean/links/543bd2880cf24a6ddb97ae9f.pdf (accessed 03/07/2015

105 Amiot-Carlin, M.J. Vice Director of the Research Unit Nutrition INRA/INSERM, France. EGEA Conference Proceedings, May, 2015. http://www.egeaconference.com/en/127/programme/ (accessed 14/08/2015).

106 The Intergovernmental Panel on Climate Change (IPCC) Climate Change 2014: Mitigation of Climate Change. Cambridge, United Kingdom: Cambridge University Press; 2014:838.

107 Scarborough, P, Appleby, PN et al., Dietary Greenhouse Gas Emissions of Meat-eaters, Fish-eaters, Vegetarians and Vegans in the UK Climatic Change 2014; 125(2):179-192

108 Meier, T. & Christen, O. Gender as a factor in an environmental assessment of the consumption of animal and plant-based foods in Germany. Int. J. Life Cycle Assess 2012; 17 (5): 550–564.

109 Berners-Lee M, Hoolohan C, et al. The relative greenhouse gas impacts of realistic dietary choices. Energ Policy 2012; 43: 184-190

110 Baroni, L, Cenci, L et al. Evaluating the environmental impact of various dietary patterns combined with different food production systems. Eur. J. Clin. Nutr 2006; 61:279–286

111 Baumgartner D U, de Baan L et al. European Grain Legumes - Environment-Friendly Animal Feed? Life Cycle Assessment of Pork, Chicken Meat, Egg, and Milk Production. Grain Legumes Integrated Project. Final Report; WP2.2, Environmental Analysis of the Feed Chain. Zürich: . Agroscope Reckenholz-Tänikon Research Station ART; 2008: 106

112 Carlsson-Kanyama A & Gonzalez AD Potential contributions of food consumption patterns to climate change. American Journal of Clinical Nutrition 2009; 89: S1704-S1709.

113 Audsley E & Wilkinson, M What is the potential for reducing national greenhouse gas emissions from crop and livestock production systems? Journal of Cleaner Production 2014; 73: 263-68.

114 Pieter van Beukering, Kim van der Leeuw et al. Meat the Truth. The contribution of meat consumption in the UK to climate change. Amsterdam, the Netherlands: Institute for Environmental Studies (IVM), VU University; 2008.

115 HM Government. Climate Change - The UK Programme. London: HM Government; 2006

116 Craig, WJ & Mangels, AR. 2009, ibid.

117 Cross AJ, Leitzmann MF et al. A Prospective Study of Red and Processed Meat Intake in Relation to Cancer Risk. PLoS Med 2007; 4(12): e325

118 Giovannucci, E, Rimm, EB Intake of fat, meat and fiber in relation to risk of colon cancer in men. Cancer Research 1994; 54(9):2390-2397.

119 Kelemen, LE, Kushi, LH et al. Associations of dietary protein with disease and mortality in a prospective study of postmenopausal women. Am J Epidemiol 2005; 161: 239-249.

120 Kontogianni, MD., Panagiotakos, DB et al. Relationship between meat intake and the development of acute coronary syndromes: The CARDIO 2000 case-control study. Eur J Clin Nutr 2008; 62:171-177.

121 Li, D, Sinclair, AJ et al. The association of diet and thrombotic risk factors in healthy male vegetarians and meat eaters. Eur J Clin Nutr. 1999; 53: 612-619.

122 World Health Organisation (WHO). Diet, nutrition and the prevention of chronic diseases. Report of a Joint WHO/FAO Expert consultation. World Health Organisation Technical Report Series. Geneva, Switzerland: WHO; 2003: 916:1-149.

123 http://www.vegansociety.com/sites/default/files/Protein.pdf (accessed 05/08/2015)

124 Bianchi, FJ J A, Booij, CJA & Tscharntke, T Sustainable pest regulation in agricultural landscapes: a review on landscape composition, biodiversity and natural pest control. Proceedings of the Royal Society of London B: Biological Sciences 2006; 273:1715-1727

125 Rattan, L. Soils and sustainable agriculture: A review. Sustainable Agriculture. 2009. Netherlands: Springer: 15-23.

126 https://www.cotswoldseeds.com/seed-info/sort-out-your-soil-practical-guide-green-manures (accessed 25/08/2015)

127 Ibid.

128 Ratten, 2009, ibid.

129 https://www.gov.uk/managing-sewage-sludge-slurry-and-silage (accessed 25/08/2015)

130 http://www.wrap.org.uk/content/using-digestate-biofertiliser (accessed 25/08/2015)

131 http://ec.europa.eu/agriculture/climate-change/index_en.htm (accessed 03/07/2015).

132 Setting the Table (2009) published by the Sustainable Development Commission. The Sustainable Development Commission is the Government's independent watchdog on sustainable development, reporting to the Prime Minister, the First Ministers of Scotland and Wales and the First Minister and Deputy First Minister of Northern Ireland.

133 The Intergovernmental Panel on Climate Change (IPCC) http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_full.pdf (page 864, accessed 11/08/2015)

134 Wirsenius, S, Hedenus, F et al. Greenhouse Gas Taxes on Animal Food Products: Rationale, Tax Scheme and Climate Mitigation Effects Climatic Change 2011; 108: 159-184.

135 http://www.foodsecurity.ac.uk/blog/2014/06/do-european-agricultural-policies-encourage-the-adoption-of-unhealthy-diets/ (accessed 17/06/2015)

136 http://www.gafspfund.org/ (accessed 14/08/2015)

137 http://ec.europa.eu/agriculture/cap-history/index_en.htm (accessed 15/08/2015)

138 "According to the Intergovernmental panel on climate change (IPPC), the worst consequences may not be felt until 2050, but significant adverse impacts are expected even in the short term from more frequent extreme conditions." http://ec.europa.eu/agriculture/climate-change/index_en.htm (accessed 03/07/2015)

139 These priorities include: fostering knowledge transfer and innovation; enhancing competitiveness of all types of agriculture and the sustainable management of forests; promoting food chain organisation, including processing, marketing, and risk management; restoring, preserving & enhancing ecosystems; promoting resource efficiency & the transition to a low-carbon economy; and promoting social inclusion, poverty reduction and economic development in rural areas.

140 Legume Futures 2014. Legume-supported cropping systems for Europe General project report.

141 European Parliament's Committee on Agriculture and Rural Development, 2013, ibid: 13.

142 European Parliament's Committee on Agriculture and Rural Development, 2013, ibid: 16

143 European Parliament's Committee on Agriculture and Rural Development, 2013, ibid: 18.

144 European Parliament's Committee on Agriculture and Rural Development, 2013, ibid.

145 European Parliament's Committee on Agriculture and Rural Development, 2013, ibid:18

146 Informal interviews with existing protein crop growers conducted by The Vegan Society.

147 "In order to encourage generational renewal, the Basic Payment awarded to new entrant Young Farmers (those under 40) should be topped up by an additional 25% for the first 5 years of installation. This shall be funded by up to 2% of the national envelope and will be compulsory for all Member states" http://europa.eu/rapid/press-release_MEMO-13-621_en.htm (accessed 03/07/2015).

148 http://www.madcowboy.com/01_AboutPS.000.html (accessed 05/08/2015)

149 https://www.abdn.ac.uk/rowett/research/strategic-partnership.php (accessed 10/07/2015)

150 http://phys.org/news/2015-08-meat-planet.html (accessed 14/08/2015)

151 http://www.lovefoodhatewaste.com/ (accessed 07/08/2015)

Responsibility for the content, conclusions and recommendations of the report rests solely with The Vegan Society.

Grow Green Report 2015/12/a

www.vegansociety.com

The Vegan Society, Donald Watson House, 21 Hylton Street, Birmingham, B18 6HJ
0121 523 1730 info@vegansociety.com