

A stylized map of the United Kingdom, including Great Britain and Northern Ireland, is positioned in the upper right quadrant. The map is filled with a camouflage pattern in shades of dark green, light green, tan, and brown. The background of the entire page is a light blue gradient that transitions into a dark green curved shape at the bottom.

Feeding Britain

from the Ground Up

ACKNOWLEDGEMENTS

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Foreword



What should I eat to be healthy and sustainable? It's a question that more and more people are asking, but perhaps unsurprisingly, the recommendations vary so much that many of us are utterly confused about how we should respond to the climate and nature crises in relation to our future diets.

This report, *Feeding Britain from the Ground Up*, from the Sustainable Food Trust seeks to provide answers to that question, based on the presumption that at least broadly, we should align our future food consumption to the output of sustainable farming systems in the regions in which we live.

Of course, context is everything and the launch of this report comes at what is arguably a critical moment in agricultural history. As I write this, the Ukraine war is causing major disruptions to our farming and food systems, nationally and globally. Even the Governor of the Bank of England has recently predicted that the conflict could precipitate a global food crisis, permanently increasing commodity prices and reducing the availability of key staple foods on which millions of people currently depend.

Against that background, some might argue that the appropriate response to a global conflict should be to further intensify

our food production methods, mirroring the 'Dig for Victory' campaign launched by the UK government during the Second World War. We certainly agree that reducing our reliance on imports, particularly in relation to our staple foods, should be treated as an absolute priority. However, we also believe that our future farming and food systems should be designed in such a way that they also address the climate and nature emergencies.

Seen in this way, the Ukraine crisis is simply speeding up a transition which already needed to happen, but until now was being held back by our reluctance to accept the implications of the end of the industrial farming era, both on food prices and future food security.

A good way to understand the implications of the Ukraine war on the food system, is to look at our response to energy supply shortages. Faced with a crisis following the sudden interruption to gas and oil supplies,

most people would accept that although we may need to continue to rely on fossil fuels to ensure short term energy security, the long-term solution is to accelerate the transition to renewable energy.

It is exactly the same with farming and food. Although the immediate priority must be to maintain supplies from existing production systems, in the medium term, it would surely be both irresponsible and myopic not to transition to farming and food systems which are resilient, food secure and address the climate and nature challenges.

Accordingly, the key questions which informed the commissioning of this report are: ‘What would sustainable farming systems look like in the UK?’ ‘How much food and of which proportions would they produce, and what would be the implications for our daily diets?’

I started farming almost fifty years ago and right from the start, I adopted biological principles, aiming to produce food in harmony with nature. As a result, I find myself in the unusually privileged position of being able to witness the effect of a nature-based farming system on productivity over a long period. The results are surprisingly gratifying. Yields are steadily increasing, and it is wonderful to witness the extent to which a wide range of wild plants, insects, birds and small mammals can coexist with a food production system which avoids the use of agrochemicals.

Through this experience, I have become increasingly convinced that farming systems

which work in harmony with nature could be applied at scale. The steady increase in productivity over such a long period strongly indicates that the system works, in terms of its impacts on soil, plant, animal and human health. There are other benefits. In the current crisis, I am much less affected by the very high price of inputs, especially nitrogen fertiliser and animal feeds. My farm should also be in a better position to withstand the greater weather extremes that climate change is expected to bring.

However, these are merely personal observations and require validation, if a case is to be made for the system I’ve been using to be more widely adopted. This is important, because throughout a lifetime of advocacy for a different way of producing food, a range of criticisms of sustainable farming have been endlessly repeated.

The first criticism — “your system could never feed the world” — reflects an understandable concern that a national or international transition to biologically based farming would simply not produce enough food. Consequently, it would increase reliance on imports, offshore our negative environmental and social impacts to other countries and leave our own farmers vulnerable to being undercut by lower standard food produced overseas.

This leads directly to a second criticism — that if the transition led to a world of higher food prices, how could we protect the right of every citizen to have access to high-quality nourishing food, regardless of income level?

A similar national debate is currently taking place in relation to energy, in response to which the Government have stepped in to help ensure energy security for lower income groups. In relation to food, short-term interventions could include an expansion of schemes which subsidise healthy and sustainable foods for low-income families, but longer-term, government can – and should – go further in tackling food poverty. The bottom line is that in cases of market failure, government has a responsibility to protect the lower income groups in society.

There is a third criticism, which the publication of this report may trigger, namely the charge that we are acting as nanny state by telling people what to eat. In fact, that was never our intention. Rather, it was the belief that many, maybe even most, informed and conscientious citizens would like to know how they could best adjust their diets to meet the current climate and nature challenges. Furnished with this information, we believe that it is reasonable to assume that many of the UK population would choose to transition to healthier and more sustainable diets.

We also hope that this report will go some way towards demonstrating that if we switched to farming systems operating inside so called ‘planetary boundaries,’ we would still be able to produce enough key staple foods to maintain current levels of self-sufficiency, providing we ate less, ate differently and wasted less.

Also underpinning the report is a sincere belief that if dietary change is to be beneficial and lasting, it needs to be based on a good public understanding of what lies behind the need for these changes in food availability and related price shifts, as well as the wider personal benefits of adopting healthier and more sustainable diets.

Mindful that some people will challenge the assumptions and methodologies which underpin this report, we have done our best to be entirely transparent about them, accepting that other approaches are also valid. In this spirit we hope the report will inform and stimulate the national debate about our future food and farming systems.

One thing is clear – that unless we turn the page from the current chapter of intensive agriculture, the problems of climate change, biodiversity loss and growing public ill-health are only likely to continue to get worse. The good news, however, is that instead of farming being one of our major environmental problems, a UK-wide farmland transition could instead enable our future farming and food systems to be part of the solution.

Patrick Holden
CEO, Sustainable Food Trust

Executive summary

A UK-wide transition to sustainable and regenerative farming practices, to tackle the climate, nature and public health crises, could produce enough food to maintain and potentially even improve current levels of self-sufficiency, provided we ate differently, ate less and cut food waste.

These are the key conclusions of our report, *Feeding Britain from the Ground Up*, which explores the potential impacts on

land use, food production and individual diets of a UK-wide transition to sustainable farming based on biological principles.

IMPACTS ON FOOD PRODUCTION

In our modelling:

- **Vegetables and fruit:** Production would double, with a greater diversity of crops being grown much more widely across the nation, often as part of mixed farming systems.
- **Grains:** Production would halve — the most significant change in food output, due to a reduction in the area of land for cereals and the elimination of synthetic inputs. This would necessitate a major reduction in the amount fed to livestock.
- **Pulses:** Production of UK-grown pulses (peas and beans) would double, due to their importance in sustainable crop rotations and for human and livestock nutrition.
- **Chicken, pork and eggs:** Chicken and pork production would decline by 75% and egg production by around 50% as a result of the end of intensive, grain-fed systems, a move to higher welfare, free-

range methods of production, and the elimination of imported protein feeds.

- **Beef, lamb and dairy:** Due to the importance of grazing livestock in sustainable farming systems, around the same amount of beef and lamb would be produced, while milk production would fall by about 25%, as a consequence of the move to pasture-based systems.

IMPACTS ON DIETS AND SELF-SUFFICIENCY

Our modelling suggests that a nationwide shift to sustainable farming would result in an increased availability of seasonal vegetables, fruit and pulses; slightly less beef and lamb and about a third less dairy, produced from high-welfare, mainly pasture-based systems; significantly less chicken, eggs and pork — with the remaining produce coming from free-range systems with high standards of welfare; and roughly the same amount of grain-based

foods, but from a greater variety of cereals including more oats and rye.

By aligning our diets to what the UK could sustainably produce and eating according to the recommended intake of calories and key nutrients, we would be able to maintain or potentially even improve on current levels of self-sufficiency.

IMPACTS ON LAND USE

- **Mixed farming:** There would be a general shift to mixed farming, resulting in the reintroduction of grassland and grazing livestock in arable areas (mainly in the south and east) and cropping in some areas which are currently dominated by grassland in the north and west of Britain.
- **More land for trees and nature:** We assumed that woodland cover would increase by close to a million hectares, and many more trees would be integrated into the farmed landscape through agroforestry. There would also be more land for nature, complementing the improvements to farmland biodiversity enabled by the shift to biologically based farming.

RECOMMENDATIONS

A rapid transition to sustainable food and farming systems will only be achievable with support from government and society at all levels. Changes in agricultural policy would need to include the redirection of subsidies, the application of the polluter pays principle and regulatory interventions.

Support from the banking, financial and investment communities would also be required to match government and food

industry measures, and to further accelerate the transition to sustainable farming.

Accommodating the increased diversity in farm enterprises and food outputs would require major investment in decentralised food processing and distribution infrastructure. Parallel investment would also be needed in people and skills.

To ensure public support for dietary change and reduction in food waste, investment in food and farming education will be key. This this will require publicly funded campaigns, aimed to harness the power of informed citizens and to promote understanding of the need to increase consumption of healthy and sustainable foods.

Food companies and retailers have a major role to play in ensuring producers are paid a fair price for their products, and that consumers are given full transparency about where and how the food they purchase has been produced.

Shifting to sustainable farming practices will likely increase food prices, as is already being experienced in the energy sector. To protect against food poverty and ensure access to high-quality food for lower income groups, government intervention will be essential.

Measuring the impacts of the agricultural transition from the farm up will also be essential, both for governments and banks providing financial support, and for consumers wishing to identify foods from sustainable production systems. To achieve this, we advocate the development of an internationally harmonised framework for measuring the impacts of farming, linked to food labelling schemes.





CHAPTER ONE

Introduction — the challenge to eat and farm sustainably

In response to the environmental and human health problems caused by our current food system, this report seeks to explore a simple question: ‘What should I eat to be sustainable and healthy?’

Around the world, millions of people are facing growing hunger and famine. In the UK, the cost-of-living crisis, driven by high energy and food prices, is pushing millions into poverty. As a country, we face a food and energy insecurity emergency for the first time in a generation. The war in Ukraine, COVID-19 and an ever-increasing number of extreme weather events have supercharged this crisis, but the truth is, it was already on its way.

Over the last sixty years, many parts of the world have undergone a process of agricultural intensification. While this has allowed the world to grow ever greater quantities of food, it has also led to farming practices which have degraded soils, reduced biodiversity, contributed to climate change, polluted our landscapes and produced a huge amount of waste.

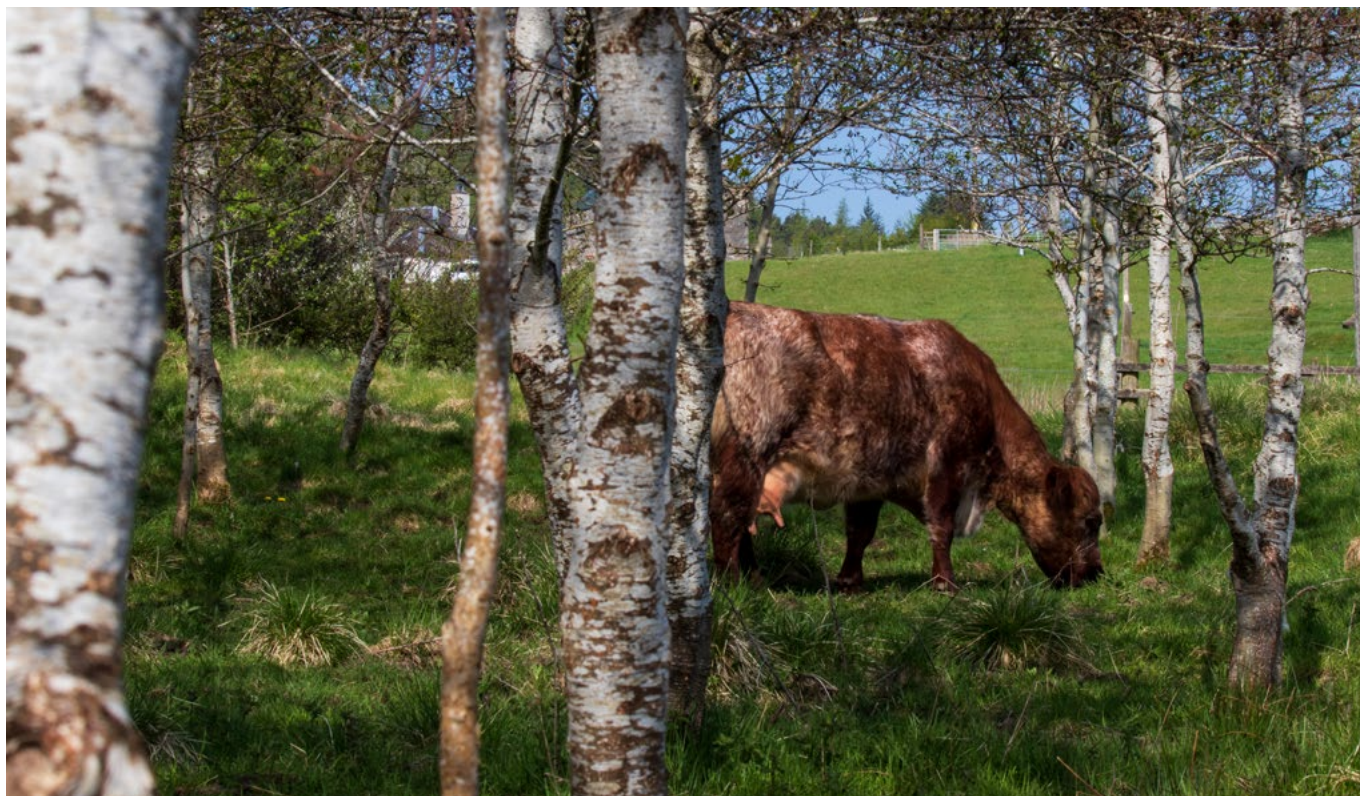
The numbers are stark. **Over a third of the arable land in England and Wales is now seriously degraded,**¹ not only leading to a major loss of carbon to the atmosphere, but also reducing the resilience of soils in the face of increasingly extreme weather linked to climate change. At the same time, agriculture has contributed to a catastrophic decline in biodiversity. In the UK, farmland bird numbers fell by 57% between 1970 and 2018,² while flying insect numbers have declined by 60% in the last twenty years.³

Industrial food production is also contributing to a global health crisis, fuelled by unhealthy diets. The increased production and consumption of ultra-processed foods has been shown to have negative impacts on human health.⁴ In the UK, 63% of adults are overweight or obese,⁵ costing society £27 billion per year — a figure that is predicted to increase to £49.9 billion by 2050.⁶

Human health is threatened by the intensification of food production in other ways too, including through the overuse of antibiotics and the increased risk of zoonotic disease. At the same time, the high-tech nature of most farming systems has led to us becoming increasingly distanced from agriculture, and consequently the story behind our food.

The scale of the problem could not be clearer, and successive statements arising from policy and climate gatherings have urged the need for change. Until now, however, calls for a global food systems transition have largely fallen on deaf ears.

There are a number of reasons for this, but what’s clear is that **the lack of consensus around what constitutes the most sustainable approach to food production,** and the subsequent public confusion about what to eat to be part of the solution, must be addressed with urgency.



The debate around land sparing versus land sharing

Broadly speaking, two approaches to sustainable food production have been put forward, and while they are not entirely incompatible, they do represent very different visions for the future of farming.⁷

The first argues that we should focus on intensifying agriculture and increasing efficiency still further, with biodiversity conserved on areas of land removed from food production. Generally termed ‘land sparing’, this approach is based on the ‘sustainable intensification’ of agriculture — aiming to produce even higher yields of crops and livestock products than at present, whilst at the same time using fewer inputs (e.g., pesticides, fertilisers, fuel and labour), and mainly achieving this through the greater use of technology. In theory, this would allow food production to be focused on as small an area of land as possible, enabling some farmland to be freed up for

nature conservation.

The second approach, termed ‘land sharing’, involves agroecological farming systems which are based on ecological principles rather than high levels of synthetic inputs, and so work *with nature*. Biodiversity and the delivery of other ecosystem services such as the natural pollination of crops, carbon sequestration, clean air and water and flood management, are therefore supported across the whole farmed landscape, and not just in areas ‘spared’ for conservation. In other words, food production and conservation go hand in hand. However, growing food in this manner usually results in lower yields due to the minimal or zero use of synthetic inputs, such as chemical fertilisers and pesticides.

In many countries, including the UK, sustainable intensification and land

sparing are generally given the most credence in debates around the future of farming. There are various reasons for this — for instance, having land that is not used for agriculture is important for the conservation of species which struggle to survive in farmed landscapes. However, the most important reason is that agroecological farming systems usually require more land to produce the same amount of food. The result of this — in theory, at least — is that more land is needed for agriculture and less land is, therefore, available for wild habitats.

There are, however, a number of potential problems with the sustainable intensification / land sparing approach, as well as the argument that we need to keep increasing yields to produce sufficient food for the growing global population. While sparing some land from agricultural use is necessary for the conservation of habitats and species that require minimal human intervention, there are areas of the world (like the UK) where some biodiversity actually benefits from, or even relies upon, nature-friendly farming practices. The idea that we can conserve nature in isolated patches of wild land has also been criticised, not least because intensive agriculture can have negative impacts on neighbouring habitats, including via the spread of pollution from farm waste and agrochemicals.

In addition, if further intensification drives increases in the supply and demand for food, there is also a risk that intensifying agriculture won't actually spare much land from food production.

Finally, there are serious questions around the future viability of intensive farming, given the increasing problems with

pesticide resistance, the need to move away from fossil fuels and energy-intensive inputs and the degradation of arable land.

In recognition of these criticisms, there has been growing interest in the potential for a land sharing approach to food production, with an increasing number of farmers adopting nature-friendly practices. Despite this, there remains a concern that with this approach, lower yields will result in less land for conservation and a potentially greater reliance on imports, and this is often used to discredit the potential of land sharing at scale.

However, this may not be the case. Our current food system is enormously wasteful: globally around one-third of the food we produce is lost each year,⁸ and 33% of the world's cropland is used to grow feed for livestock.⁹ This is an inefficient use of land and if it were instead to be used to grow crops for direct human consumption, an additional 4 billion people could be fed.¹⁰ In addition, there may also be the potential to improve on current yields in agroecological farming systems, for instance through better crop breeding.¹¹

All of this then raises the question: **if we reduce the amount of food we waste and change our diets (in particular, by moving away from the consumption of intensively-reared, grain-fed livestock products), would a land sharing approach provide us with enough food, without necessitating an increase in the area of farmland or the need for more imports?**

This report explores these issues with the aim of adding to the conversation around sustainable food production and diets in the UK.

Previous research into a sustainable farming transition

The impact of a nation-wide transition to more nature-friendly methods of food production is something which a handful of previous studies have looked at, and these serve as important precedents for this report.

In 1975, Kenneth Mellanby wrote *Can Britain Feed Itself*, so far ahead of its time that it was hardly recognised; but nevertheless, put under the microscope the question that has generally only mobilised governments during times of war.¹² While it was a very simple study that modelled a fairly conventional approach to agriculture, at a time when the population was significantly lower than it is today, the findings are still notable in that they suggest that Britain could, at that point in time, have fed itself — providing people were willing to reduce their consumption of meat.

Taking this as inspiration, farmer and author Simon Fairlie undertook a study

in 2007 which asked the same question as Mellanby by looking at whether Britain could feed itself an omnivorous or vegan diet from conventional, organic and permaculture approaches to agriculture.¹³ Once again, the conclusion was yes, if society was willing to reduce its consumption of meat — and this even pertained to the relatively land-hungry organic scenario, which performed even better when additional assumptions around the efficient use of waste, feed and methods of livestock production were applied. Although his study was published only 10 years ago, once again, it attracted little public attention, despite being of great importance.



There have also been some more academic attempts to model the impacts of a transition to agroecological farming practices. In 2009, the Soil Association commissioned Reading University to model what would happen to food output if England and Wales were to convert to organic production.¹⁴ Their findings were broadly similar to the modelling carried out more recently at Cranfield University by Laurence Smith — namely, similar or even increased levels of production for vegetables, pulses and red meat, and significant declines in the production of cereals, oilseeds, pork, poultry and milk.¹⁵ Both of these studies were, however, based on a transition to organic farming in its current form, and did not assume any changes in diet or reductions in food waste in their calculations.

A study into the impacts of a UK-wide transition to agroecology, carried out by the French institute IDDRI for the Food Farming and Countryside Commission in 2021, did just that.¹⁶ Their production findings were broadly similar to the aforementioned studies, but while they found that the UK would produce less food overall, they also found that a shift towards a healthier diet would mean that the UK wouldn't have to import any more food than it does at present. At the same time, they found that a nation-wide uptake of agroecology would allow for significant reductions in agricultural greenhouse gas emissions, and a pattern of land use that would be much better for nature. In other words, their findings indicate that by changing our diets and reducing the amount of food we waste, agroecology is a viable means of feeding the UK, while also meeting our climate and biodiversity goals.



Aims and scope of this report

Our intention with this report is to build on this growing body of evidence and add to the conversation around what constitutes a sustainable approach to food production and diets in the UK.

To do this, we carried out a desk-based study that investigated the impacts on food production, land use and diets of a UK-wide transition to farming systems which work in harmony with nature. Of course, modelling a sustainable food system that meets the needs of humans, animals and the environment is complicated and involves difficult decisions and trade-offs, and so there are limitations to this exercise. We have, however, attempted to be transparent in our approach, and have acknowledged the complexities of the issues as much as possible within the report.

In **Chapter 2** we explain the principles and practices which have informed our definition of the sustainable farming systems we have modelled in this report.

Chapter 3 provides an overview of our 4-step methodology, including how we went about calculating the impacts of a nation-wide transition to sustainable farming on land use, food production, diets and self-sufficiency.

Chapter 4 presents the results of our modelling and sets out how the UK's agricultural land would be used if farmed according to our sustainable principles, and what the impact of this transition would be on food production.

Chapter 5 assesses the implications of the changes in farming practice and total food production on the diets of individual citizens. It also looks at whether the output from sustainable farming systems in the UK could meet our nutritional needs and explores what this transition might mean for self-sufficiency and international trade, if we were to also assume a change in diets.

In **Chapter 6** we discuss the potentially significant changes in policy, finance, infrastructure, public understanding and related citizen behaviour which would be needed to enable the UK farming transition outlined in our report. These take the form of a series of conclusions and recommendations.

Our hope is that this report will help to inform the discussion about what we should eat, and how we can align our future diets more closely with the agricultural systems which will be required to address climate change, restore nature, promote public health and improve national food security and resilience in line with planetary boundaries.

Shimpling Park Farm Suffolk

John Pawsey is an organic farmer, growing arable crops and sheep on good quality agricultural land in the south-east of England. Most of the farm is under a six-year rotation, growing a number of varieties of wheat, oats and spelt for milling, barley for malting and beans, which are mainly sold for livestock feed.

Small quantities of some novel and speciality crops, including chia, lentils, peas and vetches, are also produced, and John has been successfully trialling the production of organic oilseed rape. Since conversion to organic over 20 years ago, there have been major environmental improvements on the farm, with increases in the number of farmland birds and an ongoing rise in soil carbon levels that more than offsets the farm's emissions.

However, in 2014, it was decided that the fertility-building period needed to be extended, and to make this financially possible, sheep were introduced. This has been a huge success, delivering not just an increase in soil fertility and carbon levels, but also added diversity and resilience.

Size: 649 hectares

- 550 hectares under cropping, under a six-year rotation consisting of:
 - two years of fertility-building leys, grazed by sheep
 - four years of cereal and bean cropping
- 25 hectares permanent pasture
- 20 hectares agroforestry
- 75 hectares under environmental conservation areas and woodland

Food output

- **Cereals:** 1000 tonnes for milling, 450 tonnes barley for malting
- **Beans:** 320 tonnes for livestock feed
- **Lamb:** 32 tonnes
- Plus small quantities of speciality crops
 - e.g., chia, lentils, peas and vetches

Number of employees

- On the farm, six full-time employees and a family for two months in the summer





CHAPTER TWO

Defining sustainable agriculture — Principles, characteristics and assumptions

Chapter 2 — Key principles

Summary

Rather than embrace a specific definition of sustainable agriculture (such as organic, biodynamic or regenerative), we decided to use a set of guiding principles to inform the farming systems and practices modelled in this report.

In Chapter 1, we highlighted the need for a fundamental transition of our food and farming systems to help tackle climate change, biodiversity loss and poor public health. This chapter sets out our vision for what these farming systems of the future should look like, based on three guiding principles: **‘The Farm as an Ecosystem’**; **‘The Circular Economy’**; **‘Health and Wellbeing’**.

Applied in practice, these principles would inform the design of farming systems which maximise the production of high-quality, nutrient dense food, while also:

- Minimising the use of non-renewable inputs
- Building fertility and soil health through biological processes
- Reducing and recycling waste
- Integrating crop and livestock production
- Minimising pollution
- Promoting diversity
- Delivering social and cultural benefits

Exactly how these principles and characteristics informed the modelling carried out in this study is explained in Chapter 3, which outlines our methodology. However, to help readers interpret these findings, this chapter also pulls out a number of the key assumptions underpinning this report.



As explored in the previous chapter, there are widely divergent opinions on how we should farm in order to tackle the interrelated crises of climate change, biodiversity loss and poor public health.

On the one hand, there are those who argue we should take a ‘land sparing’ or ‘sustainable intensification’ approach to farming, where intensive agricultural production is focused on the best land, thus making room for rewilding and nature conservation on the remaining areas.

At the other end of the spectrum is the ‘land sharing’ or ‘agroecological’ approach, where agriculture is based on ecological processes, resulting in less intensive, more nature-friendly farming systems, but lower yields. For the reasons set out in the previous chapter, **we have investigated a land sharing approach**, by modelling the land use, food production and dietary impacts of a transition to agroecological farming practices across the whole of the UK’s farmed landscape.

Land sharing and agroecology are broad terms, and a number of existing, well-defined approaches to farming, such as organic, biodynamic and regenerative, can all be said to fall under their umbrella. Each of these systems has been shown to deliver a wide range of benefits and will therefore have important roles to play in the future. However, as with any farming system, each has its limitations. Perhaps the biggest issue is the risk that promoting a single definition of sustainable farming can lead to siloed thinking and entrenched positions. For these reasons, we concluded that it would be preferable to model an approach to sustainable farming defined by a set of overarching guiding principles and characteristics.

To maintain consistency, throughout the rest of the report we make use of the words ‘sustainable’ and ‘regenerative’, as generic short-hand terms to capture the principles laid out in this chapter.

Guiding principles

Core to our approach is food production which works *with* nature and its fundamental universal principles:

1. The Farm as an Ecosystem

Farms are managed in ways that encourage mutually beneficial interactions between plants, animals, the farmed landscape and its people.

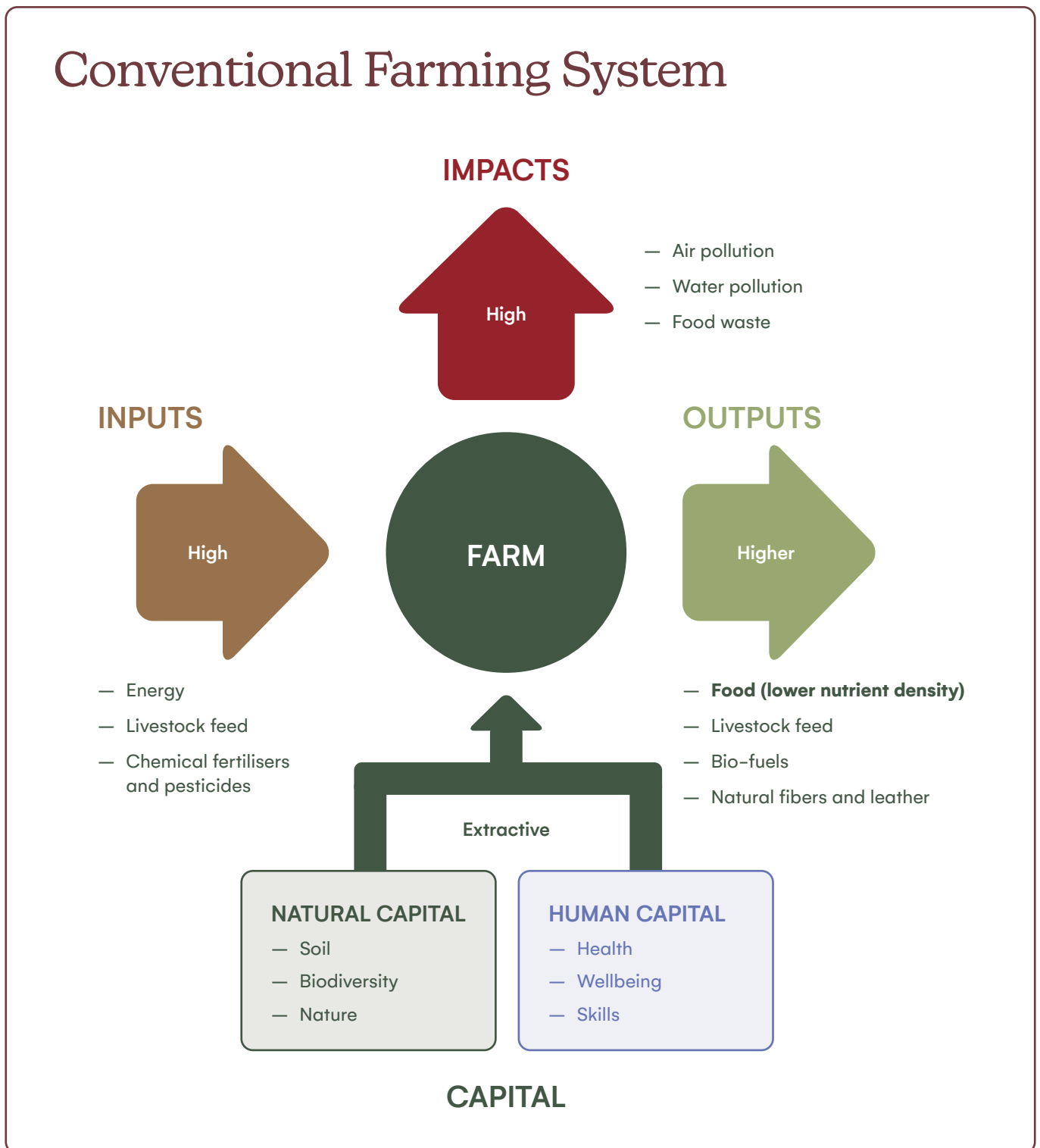
2. The Circular Economy

Farming systems incorporate the law of return, reducing and reusing waste, recycling nutrients and building natural capital through regenerative practices.

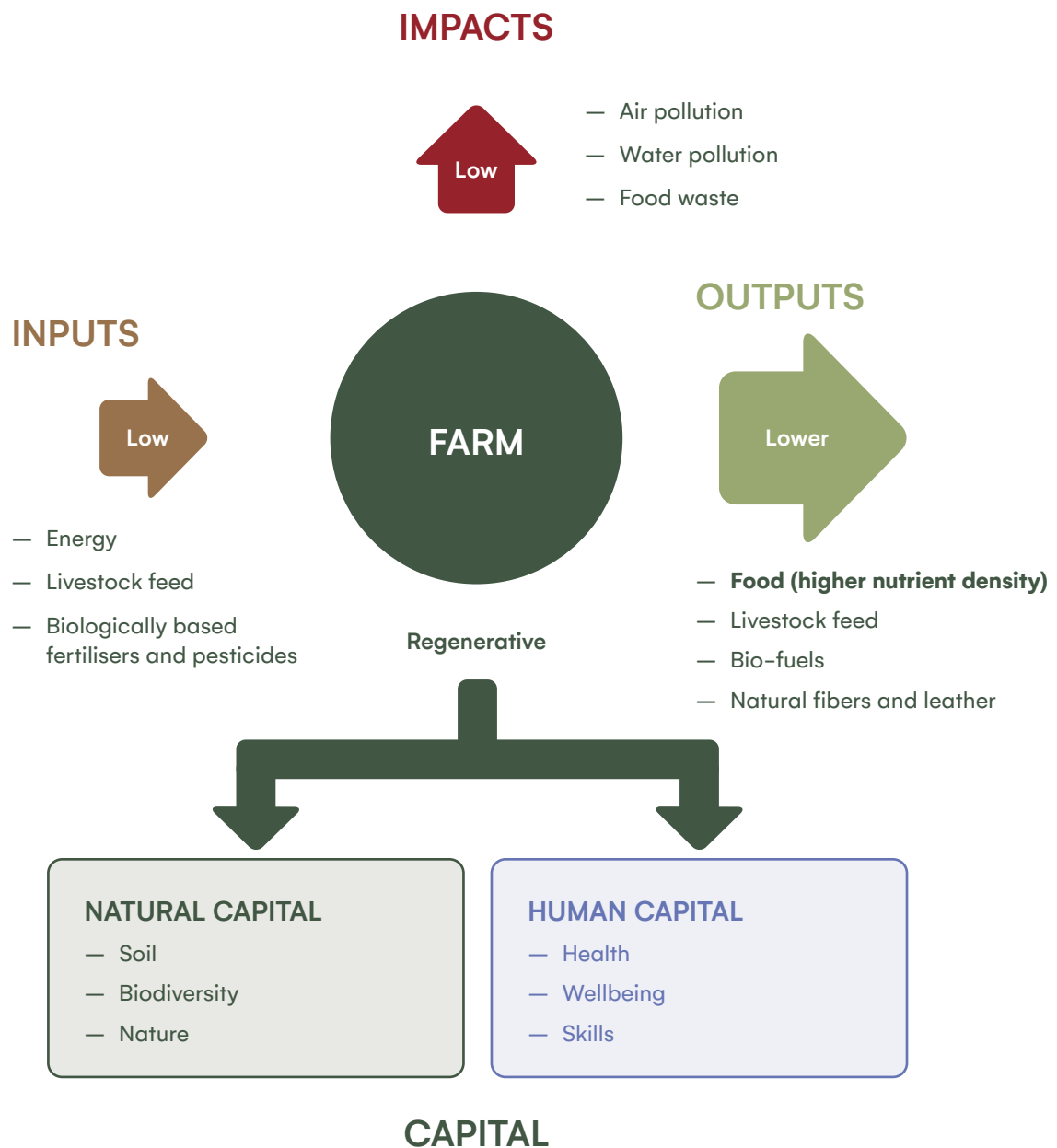
3. Health and Wellbeing

Food production systems are designed to promote the health of soil, plants, animals, people and the environment.

FIGURE 2.1: CONVENTIONAL AND SUSTAINABLE FARMING SYSTEMS — A COMPARISON



Sustainable Farming System



Key characteristics

Many farmers around the UK are already implementing some or all of these practices and principles, and there is a growing interest in sustainable agriculture across the farming sector.

The way in which these principles are expressed in practice is diverse, depending on variations in soils, climate and topography, as well as individual, social and cultural factors, as the case studies in this report demonstrate. **However, all farms and food systems which operate according to these principles share a set of key characteristics:**

- **Minimising the use of non-renewable external inputs:** A key feature of sustainable farming systems is that they minimise the use of chemical fertilisers and pesticides produced from non-renewable resources, due to their damaging impacts on climate change, biodiversity loss, food quality and human health.¹
- **Using biological processes to build soil fertility through crop rotations:** Enabling the transition away from intensive farming with its high use of chemical inputs necessitates the reintroduction of a biological approach to farming, based on crop rotations with a fertility-building phase using forage legumes (which naturally make nitrogen available for plant growth) and grasses, both of which enhance levels of organic matter and biological activity in the soil.²
- **Rearing livestock in pasture-based systems:** Appropriately managed livestock can deliver multiple benefits in sustainable farming systems. These include the capacity to convert forage into nutrient-dense food during the fertility-building phase of crop rotations and on land unsuitable for cropping as well as supporting biodiversity through appropriate grazing practices. This approach to livestock production also lends itself to the delivery of high standards of animal welfare, which is a key aim of sustainable farming systems.³
- **Reducing and recycling waste:** Reducing and recycling food and farm waste through the adoption of circular economy principles is a fundamental characteristic of sustainable food and farming systems.⁴ Examples of how this can be achieved before the farmgate include the recycling of waste and by-products through livestock and improved storage and on-farm processing facilities. After the farmgate, waste can be reduced through greater education, a relaxing of grading-out standards and better labelling and legislation.
- **Minimising pollution:** The loss of nutrients and carbon from industrial agriculture contributes significantly to air and water pollution, climate change and has negative impacts on human health.⁵ Minimising the use of synthetic inputs and fossil fuels through well-designed crop rotations, better grazing management, reduced stocking rates and appropriate manure management practices can all help to reduce pollution.

- **Promoting diversity:** The promotion of diversity is a key characteristic of sustainable farming systems. This includes the diversity of crops, genetics and farm enterprises, as well as the biodiversity which co-exists with the farming system. This way of farming encourages mutually beneficial interactions between the different parts of the farm ecosystem — encompassing everything from the integration of crop and livestock production to the benefits which diverse rotations and species-rich field margins bring to crops, farm animals and wildlife.
- **Enhancing food quality:** Producing high quality, nutrient-dense food is another key feature of sustainable farming systems. In practice, this means that there is a focus on producing a

diverse range of crops and livestock products that contribute to healthy diets, and the application of methods of production which encourage better nutrient densities and profiles in food, for instance, through pasture-based systems of livestock production.⁶

- **Delivering social and cultural benefits:** Sustainable farms can deliver a wide range of social and cultural benefits.⁷ These include higher levels of employment (positively impacting local economies and communities), greater levels of job satisfaction, improved wellbeing and greater opportunities for community engagement with the food system. The high levels of biodiversity and increased land for nature found on sustainable farms can also provide benefits to the wider community.⁸



Box 1

The importance of grazing livestock in sustainable farming systems

The intensification of livestock production has had a number of negative impacts, including on animal welfare, biodiversity and climate change, and has also led to a rise in antimicrobial resistance, with potentially major implications for human health. As a result, livestock have received a huge amount of negative attention over recent years.

What is not widely understood, however, is that **livestock, when reared in an appropriate fashion, play a vital role within sustainable food systems,**¹⁰ for a number of reasons:

- The fertility-building grass and legume phases of the rotation are an essential part of crop production systems which work in harmony with nature (see Box 2) and the only real way to produce food — and therefore income — from this phase of the rotation, is to graze it with livestock.
- Livestock can directly benefit soil health through their grazing and trampling of vegetation and via the manure they produce, helping to minimise the need for chemical fertilisers.
- They can help to suppress crop pests, weeds and diseases through their grazing, minimising the need for chemical pesticides.

— Livestock are able to consume feeds which humans can't or don't want to eat (such as grass, crop by-products and food waste), and then 'upcycle' these into nutrient-dense foods. This allows us to produce food from the extensive areas of agricultural land which aren't suitable for crop production, reduces the pressure on croplands and represents a key livelihood for many rural communities.

— Many of the UK's most important habitats and species of wildlife greatly benefit from, or even rely upon, well-managed livestock grazing.¹¹

Fulfilling this beneficial role means rearing livestock in ways that are very different to the intensive systems which supply so much of our meat, milk and eggs today.

Appropriate stocking densities; minimal use of human edible feeds and antimicrobials; outdoor-based systems with a focus on supporting biodiversity and the highest standards of animal welfare are all essential to delivering the benefits listed above.

Of course, a nation-wide transition to this approach to livestock production would have major consequences for the amount of meat, milk and eggs that we would be able to produce (and therefore consume) and would also have important implications for greenhouse gas emissions. For further discussion of these issues, see Chapter 4.



Crop rotations explained

On land used for cropping, well-designed rotations are absolutely fundamental to the management and productivity of sustainable farming systems. They are essential to building and maintaining soil health and fertility, they help control pests, weeds and diseases, and they also introduce diversity and complexity into the farming system, which promotes overall health and resilience.¹²

So how do crop rotations work? A different type of crop is sown each season on a piece of land. For example, one season a field may be used to grow wheat, followed by beans, barley and then grass. Rotations can be different lengths — for example some might be three years, others seven.

The fertility building phase of the rotation is key. This is when the land is taken out of crop production for a period of time and instead sown with a mixture of grasses, forage legumes and other species (which are generally grazed by livestock). This allows the soil to recover and to rebuild the fertility lost during the cropping (exploitative) phase of the rotation.

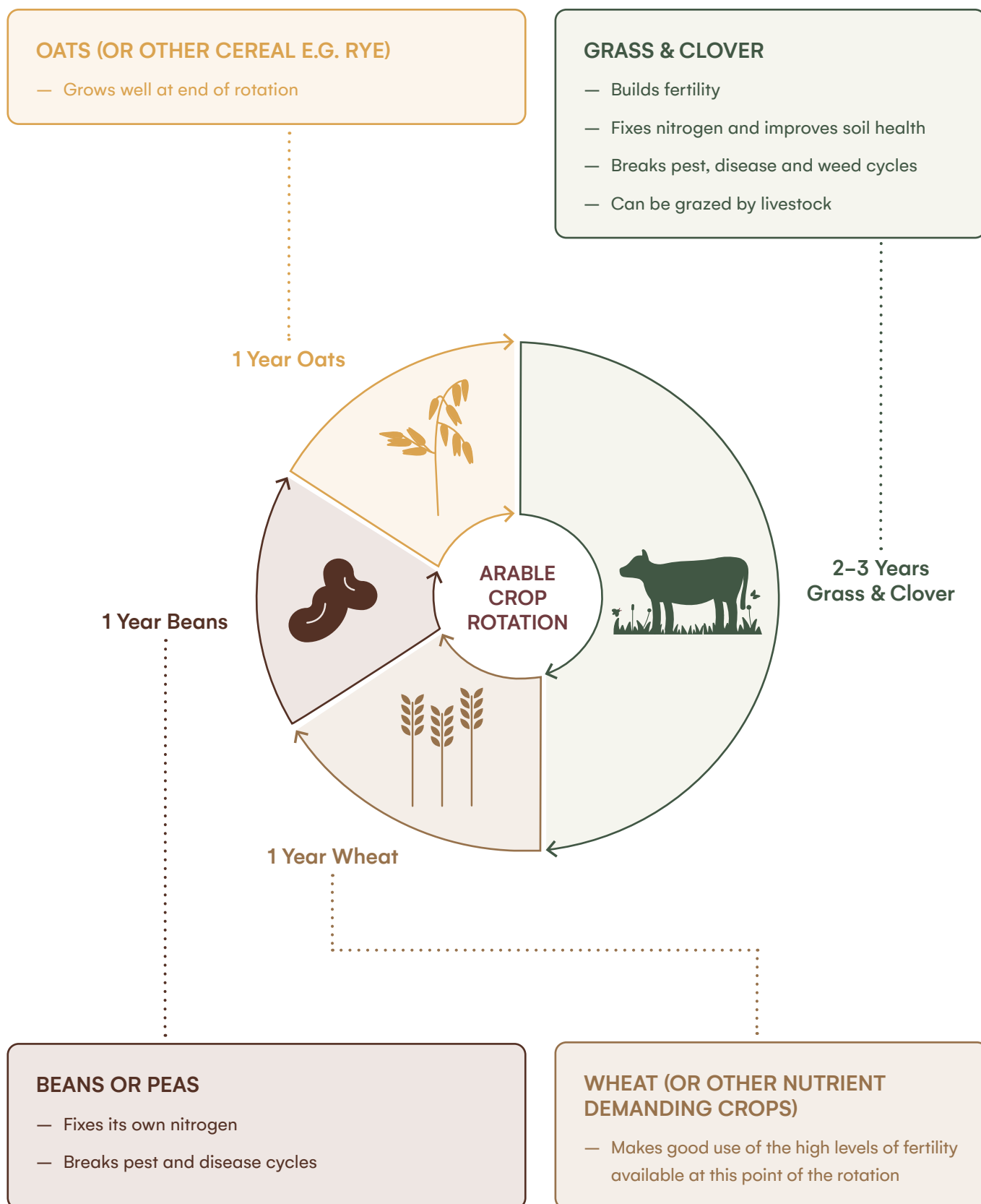
Because grasses have a very high root mass, they, in harmony with soil organisms, build fertility by turning carbon originally taken from the atmosphere by photosynthesis into stable organic

matter, which is then safely sequestered in the soil. This also helps to build soil structure, making it less prone to erosion and allowing it to hold more water. Forage legumes (such as clover) take nitrogen (a key nutrient for plant growth) from the atmosphere and convert it into nitrogen in the soil, where it can then be used by crops when the land is returned to the food cropping phase of the rotation. Livestock grazed on these temporary grasslands also help to build fertility through their manure and the stimulation of plant growth. **All of these actions help minimise or even eliminate the use of chemical fertilisers.**

Crop rotations, which include a fertility-building phase, also help to break the life cycles of pests that affect livestock, such as stomach worms, thus reducing or avoiding the need for wormers, which can have negative impacts on biodiversity. Well-designed rotations also help manage the population of weeds, pests and diseases which affect crops by breaking their life cycles, thus avoiding or reducing the need for chemical interventions.

A balanced crop rotation also ensures a greater diversity of crops is grown, leading to a more diverse farm ecosystem. This attracts a wide variety of insects and other wildlife, boosting biodiversity and general farm resilience.

FIGURE 2.2: EXAMPLE CROP ROTATION



Key assumptions

Exactly how these principles and characteristics informed the modelling carried out in this report is explained in the following chapter, which outlines our methodology. However, to make it easier to understand our approach, we have pulled out several key assumptions:

DIETS

This report is based on the proposition that **enabling the transition to more sustainable farming practices in the UK will require citizens to more closely align their diets to what we can sustainably produce**, and for this reason, we assume that the public will be willing to make changes to what they eat.

Of course, individual food choices are influenced by a variety of factors other than issues of sustainability, and so the question of dietary change is fraught with difficulty. However, it is widely accepted that changing what we eat is urgently needed for both planetary and human health. In addition, increasing weather extremes in many food producing regions, the prospect of food shortages and the dramatic increases in fertiliser prices, are beginning to focus public attention on the UK's capacity to feed itself. As such, we hope this report will make a valuable contribution to the vital debate around what we should eat to be healthy and sustainable.

FOOD SECURITY

Perhaps the most important question which informed this report is: **'To what extent would the UK be able to feed itself, were it to transition to regenerative farming practices?'** We believe it is in the public interest to have a clear understanding of the UK's capacity to achieve a reasonable degree of food security under sustainable

farming conditions — in part, because of the questions that are often raised about the implications for self-sufficiency of a move to lower-yielding farming practices, but also because there is growing concern around the UK's reliance on imported food at a time of increasing political and climatic instability.

The desire to answer this question influenced our modelling in terms of the amount of land we allocated to the production of different foods, as well as our decision to not assume the import of any animal feeds in our study, so that the UK's true level of self-sufficiency could be assessed. **It also informed our decision to assume no use of agricultural land for the production of bioenergy crops.**

CHANGES IN FARMING PRACTICE AND LAND USE

Readers of this report might legitimately question how and why the pattern of land use and food production under a sustainable farming system differs so dramatically from the present day. The reason is that such a transition would require major changes to farming practice, with some of the most important of these including:

- **No use of synthetic fertilisers and pesticides**, with fertility and pest control instead provided by diverse crop rotations, manures, cover crops, the use of suitable breeds and varieties, and the provision of on-farm habitats for pest predators



- **A return to mixed farming systems**, with crop and livestock production integrated across the country wherever possible
- **Pasture-based systems of livestock production**, with animals reared in a way that supports biodiversity and high standards of welfare
- **No use of imported protein feeds for livestock, and a major reduction in the use of cereals for feed**, with food waste, crop waste and by-products fed to animals
- **The allocation of 10% of the croppable area for on-farm habitats for nature, and a further 10% of all farmland for agroforestry**

It goes without saying that there is a huge variation in the productive capacity of the UK's farmed landscapes, ranging from mountainous regions with severe constraints on food production at one end of the scale, to highly fertile soils in the lowlands at the other. Accordingly, we

developed a number of representative farming systems, designed to reflect these differences in agricultural capability as well as the principles and characteristics set out in this chapter.

In designing these systems and allocating them to land across the UK, we have exercised a degree of choice in relation to the amount of land given to each system and crop/livestock enterprise, and the way in which these are managed. Rather than base these choices on the existing pattern of land use across the UK, we have allocated land to farming systems and enterprises according to the area of land suitable for their production, while also taking into consideration the need to avoid over- and under-production of different foods, the need to move towards a more regionally diverse pattern of food production, as well as other practical and environmental considerations. These choices have been made as transparent as possible in our methodology and we acknowledge that other enterprise mix options are possible.

FARM PRODUCTIVITY

The UK-wide adoption of sustainable and regenerative farming systems will inevitably have an impact on yields per hectare of crop and livestock products. Once again, we have made a series of assumptions about the yield capacity of these biological farming systems, which are also open to challenge. Perhaps the biggest negative impact will be on yields of certain arable crops, including wheat, barley and oilseed rape, as well as on the yields of chicken and pork, much of which is at present produced intensively. Other crops, however, would see less of a decline in yield, including pulses such as peas and beans, oats and many field vegetables. To keep the assessment as simple as possible, we have based our modelling on existing organic yields, but assumed a 20% increase for crops, in reflection of the potential that exists to increase yields through breeding programmes and other innovative practices.

It is worth adding a note about how farm productivity should be measured. Until now, farm productivity has mainly been assessed on the weight of food produced per area of land, without taking into account nutrient density or the number of people this food would actually feed. However, there is a strong argument that we should move from assessing yields per acre, to assessing nutrition per acre, as this is a more meaningful measure of productivity.¹³ With a couple of exceptions, we haven't factored changes in nutrient density into our calculations, partly because this is a developing area of research and partly because we only looked at the supply of a few key macronutrients. However, **the concept of nutrition per acre has very much informed our assumptions around the prioritisation of human food production on arable land** (rather than feed), as well as around the allocation of land to a wide diversity of different crops.

WASTE

Given the major negative impacts associated with food waste, one of our key assumptions, factored into our calculations, is a reduction of food waste in different forms.

This report assumes a 50% reduction in food waste beyond the farmgate, in line with the target of the Courtauld Commitment.¹⁴ We also assume that a portion of both food and crop waste would be fed to livestock, alongside crop by-products and whey. Farming systems would also become less wasteful through a move from grain-based livestock systems (which represent an inefficient use of crops which humans could eat) to pasture-based ones, with arable land being primarily used for growing crops directly for human consumption.¹⁵

INNOVATION AND TECHNOLOGY

Some people conflate a biological approach to food production with a rejection of science, innovation and technology in agriculture. However, **new technologies and practices will have an important role to play in improving the sustainability of regenerative farming systems**, and so we have assumed the use of some of these in our modelling. Novel and alternative sources of feed (such as heat-treated food waste), rotational grazing systems, intercropping and breeding programmes for better crop varieties for low-input farming systems are some examples of agricultural innovations which we've either modelled or assumed the use of. However, there are many other new and innovative practices and technologies which we haven't taken into account either due to a lack of data on their impacts, or because they are meant to reduce environmental impacts (which we haven't attempted to model), including

the breeding of more efficient and lower methane-emitting livestock and remote-sensing of soils and crops.

INFRASTRUCTURE AND DEMAND

A key assumption of this report is that to enable the transition to sustainable farming systems, the necessary increases in skills, workforce and infrastructure would be achieved, alongside changes in consumer behaviour and government policy. Without these, transformative and long-lasting change will not be possible. Further thoughts on this, as well as on some of the other enabling conditions necessary for the transition to sustainable farming systems can be found in Chapters 5 and 6.

CLIMATE CHANGE

The debate about the role of agriculture in helping the UK reach net zero is currently hotly contested. It wasn't within the scope of this report to measure the climate impacts of the changes in the farming practices we modelled — this is something which IDDRI's recent report did, showing that **agroecology could deliver major reductions in emissions and increases in carbon sequestration**.¹⁶ However, the need to tackle climate change was something that featured heavily in our assumptions. We modelled a number of practices which would likely have a positive impact on carbon sequestration and greenhouse gas emissions, including, the inclusion of temporary grasslands in arable areas, a significant increase in the area of woodland and agroforestry, an increase in the length and better management of hedgerows, better grazing management and lower stocking densities and the end of nitrogen fertiliser (this is expanded upon in Chapter 4).¹⁷

NATURE

As we discussed in Chapter 1, there is currently a debate about whether reversing the decline in biodiversity will be best achieved through a land sparing or land sharing approach. While these two positions exist on a spectrum, and are by no means entirely incompatible, this report is predicated on the adoption of a land sharing strategy. Again, it wasn't within the scope of this report to measure the impacts on biodiversity arising from the changes in farming practice which we modelled.

However, as with the need to tackle climate change, biodiversity restoration is an intended outcome of the sustainable farming practices featured in this report.

Further details on this can be found in the following chapter, but our assumptions around a significant increase in the area of croppable land left aside for nature, agroforestry and hedgerow cover, the use of rotational grazing systems, a general reduction in stocking densities, an increased diversity of crops and the elimination of chemical inputs would all have very positive impacts on nature.¹⁸ In recognition of the fact that certain habitats and species benefit from no or very low levels of agricultural activity,¹⁹ we have also assumed the removal of some more marginal land from food production, to be used for woodland expansion and 'rewilding'.

Blaencamel Farm Ceredigion

Blaencamel is a 50-acre holding in West Wales run by Peter Segger and Anne Evans. They have been certified organic vegetable, fruit and salad producers for 48 years.

The production system relies on a crop rotation based on 15 acres of field vegetable crops, 1.5 acres of multi-span tunnels (none of which are heated) and the rest is a mixture of grass/clover leys, green manures, woodland, hedges, a compost site and packing sheds. Key to the marketing of the farm's output are the tunnels which extend the seasons and provide year-round employment.

Peter and Anne estimate that providing Wales with the majority of its fresh produce requirements would necessitate around 200 Blaencamel-type units for specialist salad and vegetable production, with a significant number of larger farms each supplying the principal bulk crops, e.g. potatoes and carrots. The system is not climate sensitive, and also has many environmental advantages. For instance, Peter and Anne's records show that the farm is carbon negative and has been for some time.

Blaencamel produces over 50 individual crops annually, but the principal ones are fresh salad packs (approx. 20,000 retail packs), kale (around 16,000 retail packs), 10 tons of sprouts and 45 tons of potatoes (as an example).





WEIGHT (KG)
0.848

UNIT PRICE

TOTAL PRICE



CHAPTER THREE

Methodology: Modelling sustainable food production across the UK

Chapter 3 — Methodology

Summary

This chapter explains how we modelled the land use, food production and dietary impacts of a nationwide shift to sustainable agriculture in the UK.

To achieve this, we created a set of farming systems, each adhering to the core sustainability principles set out in Chapter 2 and designed to reflect the wide variation in agricultural capability seen across the UK.

We then allocated these systems to the UK's agricultural area and calculated the amount of food they would produce. Finally, we investigated what the changes in production might mean for future diets and levels of self-sufficiency.

The first stage was to divide the UK's farmland area according to variations in agricultural capability, ranging from the best quality farmland in the lowlands, capable of growing a wide range of crops, to land limited to low densities of grazing livestock in parts of the uplands. This also included designating some land for woodland expansion and nature restoration.

Using the principles set out in Chapter 2, we then designed a set of sustainable farming systems and allocated an area of land to each of these, taking into account

agricultural capability, as well as the need to avoid over- and under-production of certain foods. For example, on the best quality agricultural land, we allocated a mixed cropping and livestock system, with 50–60% of the rotation used to grow a wide variety of crops and the remainder in a fertility building phase, typically grazed by livestock.

Next, we calculated the amount of food that this nation-wide approach to sustainable farming would produce. We used data from a range of sources, including published figures on current organic yields in the UK, but assumed a 20% uplift in these, based on the potential for improvements through future research into plant breeding, and practices such as intercropping.

The final step was to calculate what impact this transition might have on the diets of individual citizens, as well as the implications for UK food security and international trade 10 years in the future, when the population is predicted to be approximately 70 million people.

This chapter outlines our approach to modelling a nation-wide transition to sustainable agriculture in the UK.

In undertaking this study, it was necessary to make a number of assumptions around various factors, including the allocation of resources to different crops and livestock, the area of land used for non-agricultural purposes and levels of productivity. Mindful that these assumptions are open to challenge, we have been completely transparent about them throughout the report. Further details on our methodology are available on request from the author.

Step 1: Divide the UK's farmland area according to variations in agricultural capability

The UK's agricultural area, covering more than 70% of the country,¹ is hugely diverse, ranging from highly productive lowland soils capable of producing a wide variety of crops, to upland areas with severe environmental constraints that limit farming activity to low densities of grazing livestock. Dividing the UK's farmed area, based on an assessment of the variation in agricultural capability across each of the four nations, was therefore the first step in our modelling.

To do this, we used data from two land classification systems:

- the Agricultural Land Classification (ALC) system, used in England, Wales and Northern Ireland²
- the Land Capability for Agriculture (LCA) system, used in Scotland³

Both these systems use soil, climate and topographical information to determine and map agricultural capability across the home nations, with land categorised into 'grades' or 'classes' — grade 1 being the best quality agricultural land and grade 5 (or in the LCA, class 7) being the most limited. While these systems differ in some ways, to allow for a UK-wide comparison and to avoid unnecessary complications, we 'converted' LCA classes to the most closely corresponding ALC grades, with a description of each of these provided in the list below. We then took data on the area or percentage of each nation under the different grades or classes of land and applied these to the official government figures on the current area of farmland, which then provided us with a good approximation of how agricultural capability varies across the UK.⁴

AGRICULTURAL LAND CLASSIFICATION (ALC GRADES):

Grade 1: Excellent quality

Land with no, or very minor limitations to agricultural use. A very wide range of agricultural and horticultural crops can be grown. Broadly corresponds to LCA class 1.

Grade 2: Very good quality

Land with minor limitations which affect crop yield, cultivations or harvesting. A wide range of agricultural and horticultural crops can usually be grown. Broadly corresponds to LCA class 2.

Grade 3a: Good quality

Land capable of consistently producing moderate to high yields of a narrow range of arable crops, especially cereals, or moderate yields of a wide range of crops. Broadly corresponds to LCA class 3.1.

Grade 3b: Moderate quality

Land capable of producing moderate yields of a narrow range of crops, principally cereals and grass, or lower yields of a wider range of crops, or high yields of grass which can be grazed or harvested over most of the year. Broadly corresponds to LCA classes 3.2–4.2.

Grade 4: Poor quality

Land with severe limitations which significantly restrict the range of crops and/or level of yields. It is mainly suited to grass with occasional arable crops (e.g., cereals and forage crops). Broadly corresponds to LCA classes 5.1–5.3.

Grade 5: Very poor quality

Land with very severe limitations which restrict use to permanent pasture or rough grazing, except for occasional pioneer forage crops. Broadly corresponds to LCA classes 6.1–7.

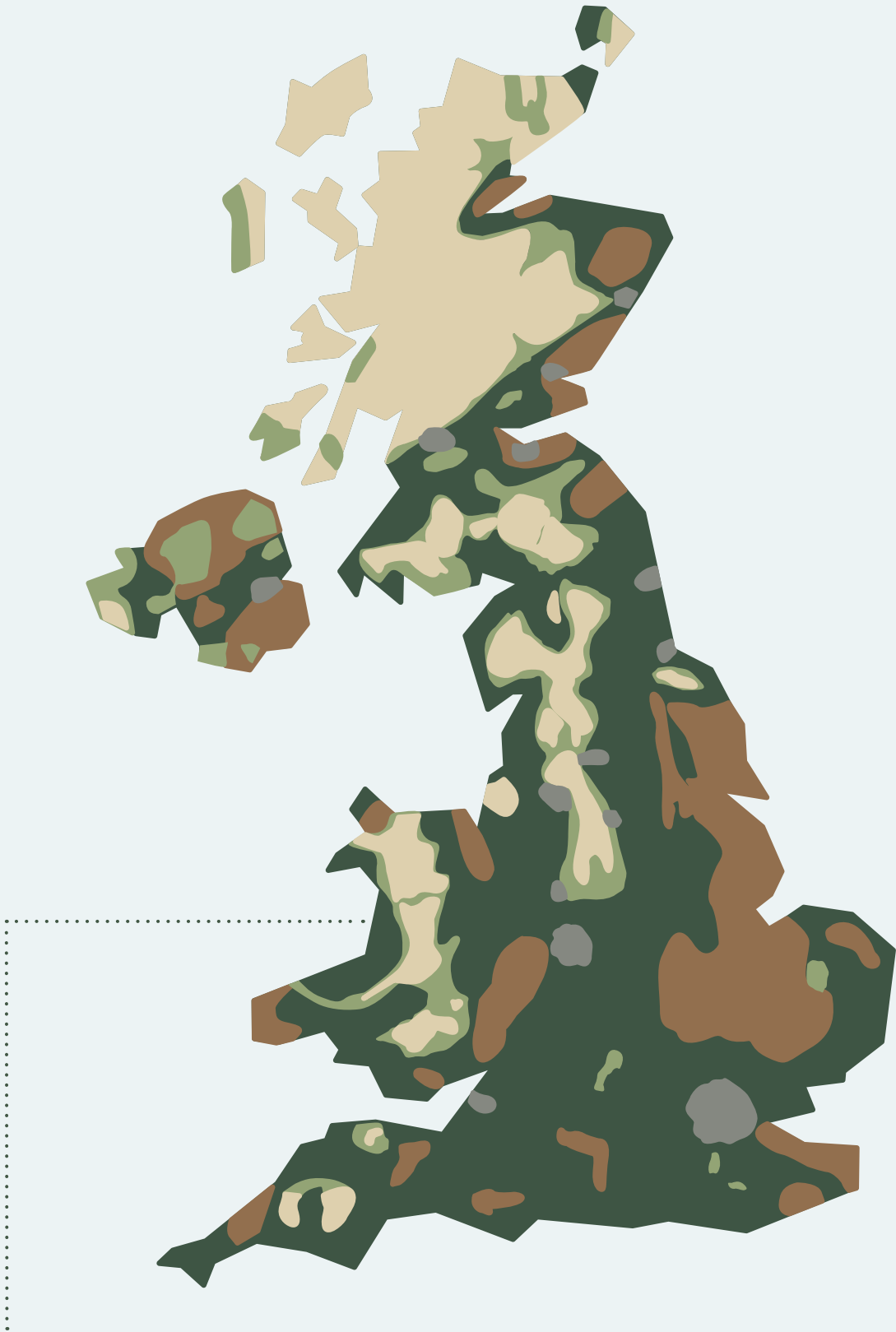
Figure 3.1* illustrates the very significant variations in the quality of agricultural land across the UK, which in turn determines the types and quantities of food that can be produced. As the map also shows, the quality of agricultural land is unevenly spread across the home nations.

For example, the best quality grade 1 and 2 land covers a significant area in England, but is extremely limited in Scotland. In contrast, the poorest quality grade 5 land covers a relatively small portion of England's total agricultural area, but makes up over a quarter of Wales' and over half of Scotland's agricultural area. These variations are shown in Figure 3.2**.

* Figure 3.1 is a schematic representation of official ALC and LCA maps, and so is not intended to show the exact distribution of grades.

** ALC and LCA breakdowns in Figure 3.2 were provided by Natural England, the Welsh Government, the James Hutton Institute and DAERA.

FIGURE 3.1: HOW THE QUALITY OF AGRICULTURAL LAND VARIES ACROSS THE UK



Grade 1, 2 & 3a
The best quality agricultural land

Grade 3b
Lands with increased constraints on crop production

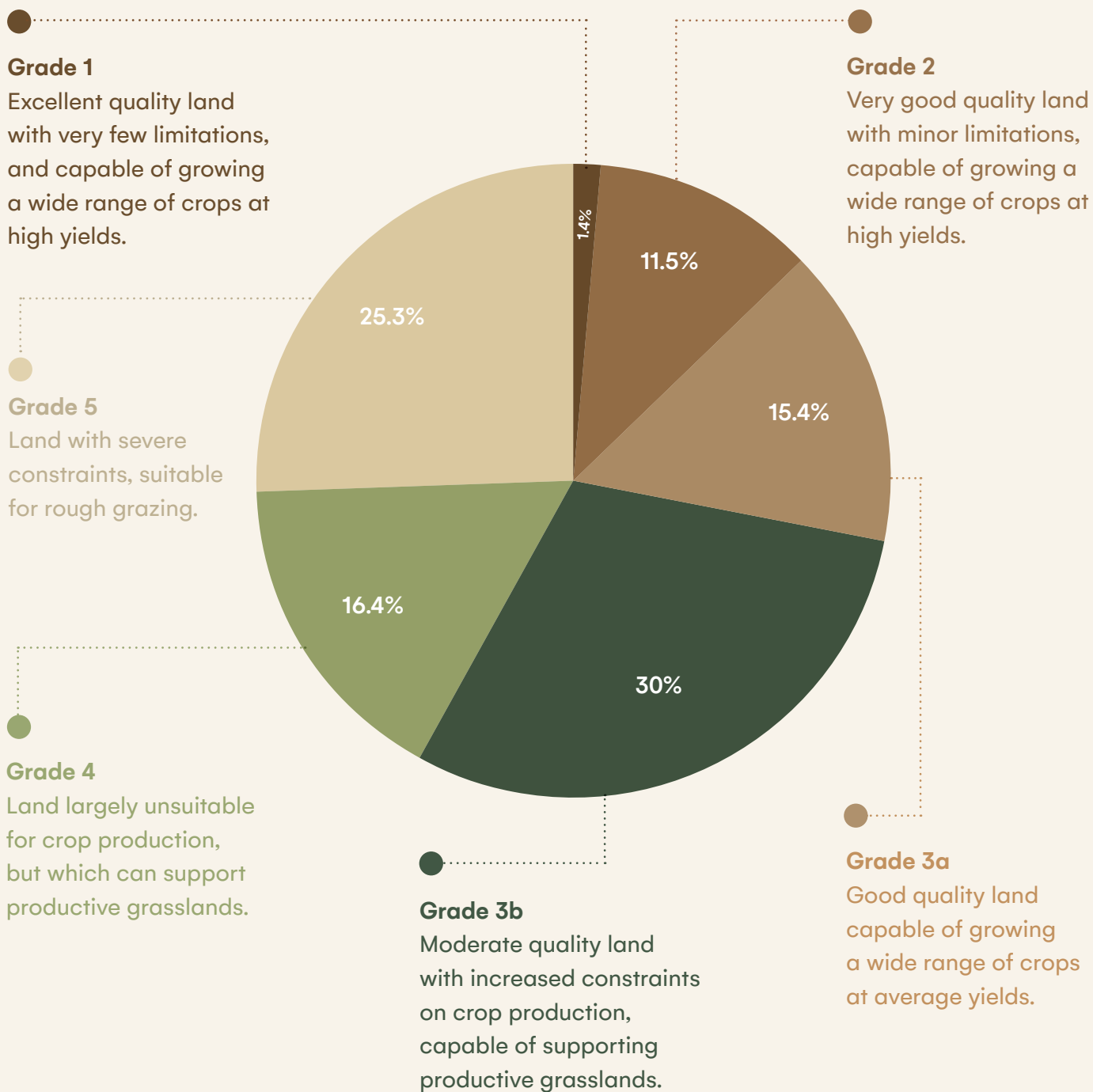
Grade 4
Land suitable for productive grasslands but not crops

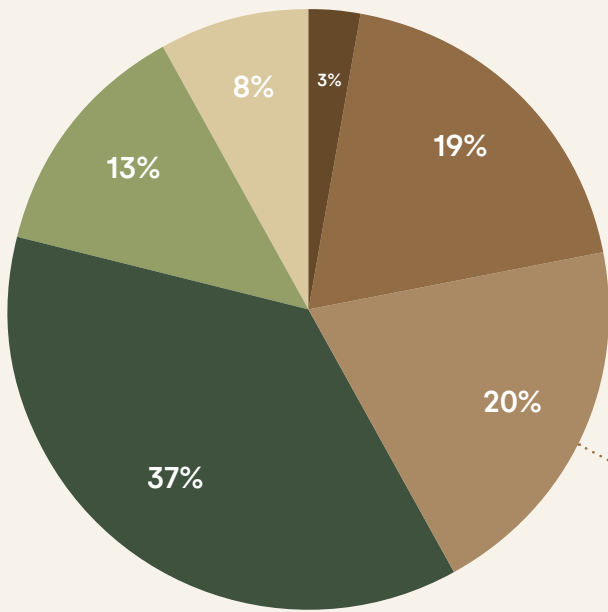
Grade 5
Land suitable for rough grazing

Urban areas
Cities

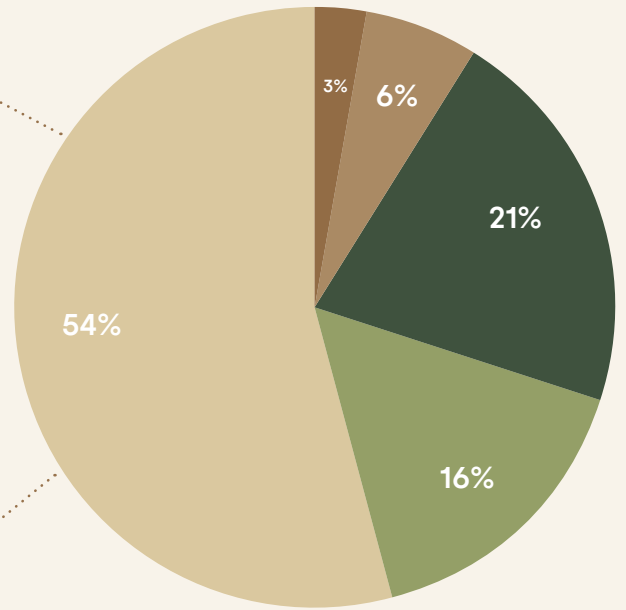
FIGURE 3.2: THE CAPABILITY OF AGRICULTURAL LAND IN THE UK AND HOME NATIONS

United Kingdom

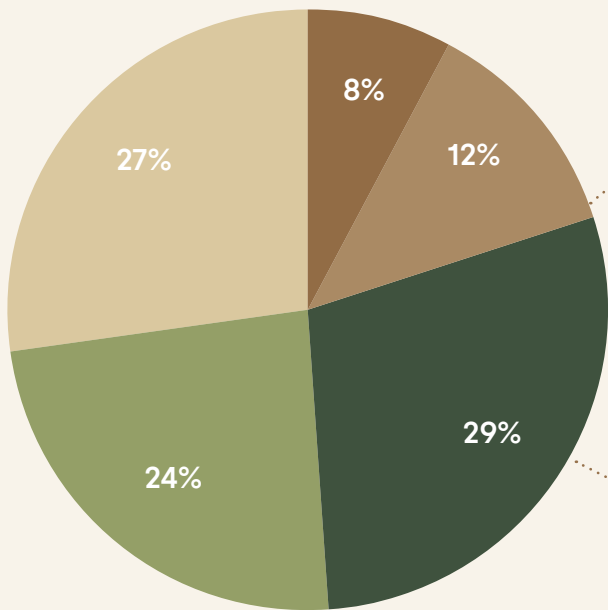




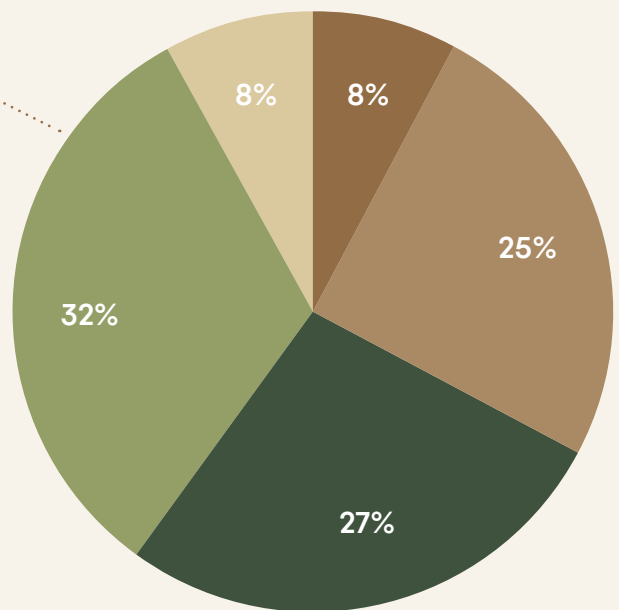
England



Scotland



Wales



Northern Ireland

CAPABILITY OF AGRICULTURAL LAND ACROSS THE UK

Across the UK as a whole, just over a quarter of all farmland is classified as ‘prime’ agricultural land (ALC grades 1, 2 and 3a), capable of growing a wide range of crops with consistently good yields. However, as a result of more than half a century of continuous arable cropping, much of this high-quality land is in a state of diminished fertility, with 38% of cropland in England and Wales in a degraded condition.⁵

Mindful of this threat to the potential productivity of the best land and the need to restore it to good health, our modelling entails the introduction of farming systems which incorporate diverse crop rotations, which include a fertility-building phase, normally of clover and grass, as these have the ability to rebuild soil carbon levels and overall soil health.

A further 30% of the UK’s agricultural land is categorised as ‘moderate’ (ALC 3b or LCA 3.2–4.2) — still capable of growing a range of crops but with lower yields and a greater percentage of grassland being necessary in the rotation, due to the more significant soil and environmental constraints.

This means that close to 60% of the UK’s agricultural area is technically capable of being used for at least the occasional production of food crops. In reality, however, there are various practical and environmental reasons why a significant percentage of this land should be left as permanent pasture.

Above all else, using all of the UK’s potentially croppable land for crop production would require the conversion

of millions of hectares of permanent grassland, a scale of land use change that would result in a major loss of carbon and nitrogen from the soil into the atmosphere, and would likely have negative impacts on biodiversity, water quality and flooding.⁶

That said, there are good arguments why some of the land which is currently under permanent grassland could be used to grow occasional crops as part of a long-term rotation. The area of land under arable production in the UK has actually shrunk by over 1 million hectares since 1950, largely because of the move away from mixed farming systems to more specialised grazing livestock systems in parts of the north and west of the country.⁷ Reversing this trend, to at least some extent, would allow for a greater and more diverse abundance of food to be grown in many areas currently dominated by improved pasture, but it could also provide major benefits for biodiversity, and in particular those farmland species which benefit from sustainable arable production.⁸

While arable production is possible on some grade 4 land, most of the final 40% or so of the UK’s agricultural area is only really suitable for grass and grazing livestock (ALC grades 4 and 5, broadly corresponding to LCA 5.1–7). Of this, just under 40% is classified as grade 4 land (which in Scotland, is equivalent to grades 5.1–5.3) generally capable of supporting productive grasslands, while the remaining 60% is grade 5 land (grades 6.1–7 in the Scottish system) which due to severe environmental constraints, is effectively limited to rough grazing — i.e., pastures made up of native plant species which are often of limited nutritional quality, and which are therefore only capable of supporting hardy breeds of sheep and cattle kept at low densities.

ALLOCATION OF LAND FOR WOODLAND AND NATURE

Biodiversity, carbon storage and timber production can all co-exist with food production. For instance, there is significant potential to integrate trees and timber production into farming systems through agroforestry and hedgerow trees, without the need for any major reduction in the area of land used for food production.

However, to reach the nation’s climate and nature targets, setting aside some current agricultural land for other purposes is still likely to be necessary.

To achieve this, we assumed that 0.9 million hectares of grade 4 and 5 land would be used for woodland creation, in line with the recommendation of the UK Climate Change Committee.⁹ While it is not the purpose of this report to prescribe specific models of woodland creation, it is vital that this is done in an integrated and sustainable manner. For instance, blanket afforestation of entire farms and landscapes, mainly with Sitka Spruce,

is an approach to woodland creation and timber production that can be bad for biodiversity, scenery, rural communities and resilience against climate change.¹⁰ However, timber does not need to be produced in this way — growing trees at smaller scales and with a more diverse range of species is entirely possible, providing benefits for biodiversity and rural communities, as well as farmers.

We also allocated a further 1 million hectares of grade 5 land for nature restoration.

Although this would reduce the land area allocated to upland farming, close to 3 million hectares of grade 5 land would remain in agricultural use. On at least some of the land allocated to nature, livestock could still be grazed at low densities, playing a key role in supporting biodiversity. However, in many cases peatland restoration and native woodland expansion — both of which will bring huge benefits for carbon storage and biodiversity — will require, or at least benefit from, the near total removal of grazing for a period of time.



Step 2: Design sustainable farming systems for each land type

Having created a land base for this study, our next step was to design a set of sustainable farming systems, based on the principles and characteristics outlined in the previous chapter, each of which is compatible with the productive capacity of particular grades of land.

Accordingly, the amount of food that these farming systems can produce varies considerably, from high levels of productivity in the most fertile areas, to much lower yields of a restricted range of foods in upland areas, where a lighter agricultural intervention is necessary.

To reflect these variations in productive capacity, we devised four primary production systems with a set of variants, each of which is compatible with a particular grade of land:

Grades 1, 2 and 3a: The best quality agricultural land

Predominant farming system: Mixed arable and livestock

This diverse production system would occupy much of the UK's most fertile land and provide us with a wide range of our key staple foods, including grains, pulses, vegetables, fruits and livestock products.

Alternative 1: Stockless arable

A stockless arable system would produce crops for human consumption but without the integration of livestock, instead using shorter but more frequent fertility building periods and green manures.

Alternative 2: Specialist horticulture (vegetables)

A more specialised and biologically intensive approach to vegetable production would also be carried out on some of the land within this category.

Alternative 3: Specialist horticulture (fruit)

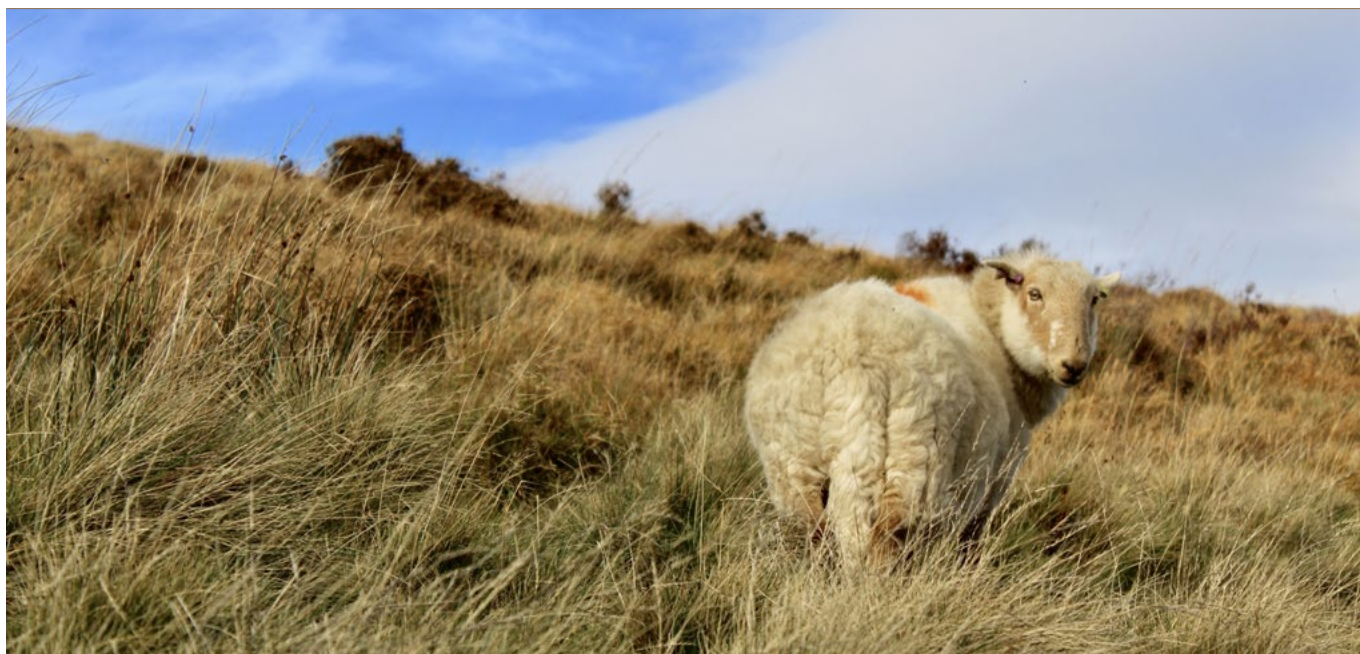
Similarly, some land would be used for growing a variety of orchard fruits and soft fruits.

Grade 3b: Land with increased constraints on crop production

Predominant farming system: Mixed livestock and arable

On less fertile arable land, grazing livestock would form the main focus of food production, but a variety of crops including cereals, pulses and vegetables would still be grown.

To enable greater regional diversity in food production and the decentralisation of food distribution, our modelling includes a small allocation of grade 3b land to specialist horticultural enterprises.



Grade 4: Land largely unsuitable for crop production but which can support productive grasslands

Predominant farming system:

Grazing livestock

On land that is unsuitable for crop production, but which can generally support productive grasslands, grazing animals would be used to turn grass into foods that humans can consume, in the form of meat and dairy.

Grade 5: Land limited to extensive, rough grazing

Predominant farming system:

Extensive grazing

On the least fertile and most constrained land, occupying large areas of the UK's uplands, hardy breeds of cattle and sheep would be reared at low densities on native grasslands and moorlands.

A description of each of these farming systems is given later in the chapter, but there are some general points worth making first:

The systems and livestock enterprises modelled here should be treated as **guides or templates**. In reality, many farms contain a mix of different grades of land, and so individual farms might support a combination of the different systems and enterprises modelled here. For instance, many specialist horticulture operations will combine vegetable and fruit production.

Similarly, while we have had to be **prescriptive in the proportion of land used for different crops and livestock within each system, these are average figures (taken largely from the organic literature) applied across all the land to which that system might apply**. Individual farmers adopting one of these systems might, therefore, have a mix of crop and livestock enterprises that differs from the averages described in this study. For instance, in the 'Mixed arable and livestock' system, we assume that 35–40% of the cropped land would, on average, be used to grow cereals, but some farms may choose to have a lower percentage than this and would allocate more of their rotation to field vegetables.

There are also some key assumptions common to all of the systems (or at least, where these are relevant). While some of these were mentioned in Chapter 2, they are worth expanding on and reiterating here:

- **Fertility:** In this study, we have assumed biologically based farming systems with no use of synthetic fertilisers and pesticides. Fertility is generated through the use of crop rotations including a fertility-building phase. We have also assumed that livestock will normally utilise this phase of the rotation, with the use of their manures also helping to provide fertility. Alternatively, in stockless systems, plant materials produced during the fertility-building phase can be cut and mulched or composted.
- **Pest control and on-farm habitats:** Crop management without the use of pesticides (as per our modelling), is made possible through management solutions such as the use of well-designed crop rotations, more resilient crop varieties and the provision of suitable habitats for pest predators. This latter point is reflected in our assumption that **10% of croppable land in our model would not be under agricultural production, to provide on-farm habitats for wildlife.** This area includes the land needed for a 40% increase in hedgerow length (as recommended by the Climate Change Committee and others) but could also include features such as species-rich field margins and on-farm wetlands, scrublands and woodlands.¹¹
- **Pasture-based systems:** We have also assumed that livestock in these systems are predominantly pasture-fed, with animals kept at lower densities than is often the case at present and grazed in a way that delivers benefits for biodiversity and supports high levels of animal welfare. On temporary grasslands and improved pasture, the stocking densities have been based on those achieved in organic systems, while on rough grazing land, they are taken from advice on the conservation grazing of natural habitats.
- **Utilisation of arable crops:** Although the feeding of cereals and other arable crops to animals increases productivity, livestock are highly inefficient at converting human-edible crops into meat, milk and eggs. The feeding of vast quantities of cereals to livestock therefore results in a major loss of calories and nutrients from the food system.¹² This, along with the substantial reduction in grain production which we modelled, led us to assume that **most arable crops would be used for human consumption, rather than for livestock feed.** As a result, the quantity of grains and other arable products available for feeding livestock will decline dramatically, with major implications for the future structure and composition of the UK livestock sector.
- **Imports of livestock feed: Another key livestock assumption is the elimination of all imported livestock feeds, including soya bean meal.** These are at present a key ingredient in pig and poultry diets in particular, but their production is associated with devastating habitat loss overseas.¹³

-
- **Feeding of food waste:** We have also assumed that monogastric livestock (poultry and pigs) would consume a greater quantity of human inedible feeds than today, including forage. In addition, **we have assumed that 40% of food currently wasted beyond the farmgate would be heat-treated and fed to pigs (as well as a small amount to poultry)**, a once-common practice that was banned across the EU after the 2001 Foot and Mouth Disease outbreak, caused by one farmer feeding untreated waste to pigs. However, this is still practiced safely and successfully in other countries such as Japan and South Korea.¹⁴
 - **Agroforestry:** We have assumed that **agroforestry (the integration of trees and agriculture on the same area of land) would be practiced on 10% of the land in each system.** We've made this assumption because of the wide range of farm and environmental benefits that agroforestry can deliver, including a diversification in farm enterprises, improved protection from the weather for crops and livestock, increased biodiversity and carbon sequestration.¹⁵ On good to moderate quality land (grades 1–3b) we've assumed an agroforestry model based on widely-spaced lines of trees, many of which would yield fruit, with wide avenues between each row allowing for arable and/or grass cropping.¹⁶ On grade 4 and 5 land not suitable for crop or hay/silage production, we've assumed a higher density of trees that would instead be used for timber and other non-food purposes.¹⁷
 - **Allocation of land to different systems and enterprises:** Where a number of different farming systems could be applied to the same grade of land, we took several factors into consideration when deciding how to allocate the UK's agricultural land area. The suitability of systems to each grade of land was the most important of these, but we also took into consideration the need to match production with predicted demand. Another consideration was the potential for regional diversification in food production. We therefore allocated a small percentage of 3b land to specialist vegetable and fruit production, which is currently rare on this land grade, though entirely possible. **The decision to expand vegetable and fruit production across the country was also informed by a desire to increase the UK's consumption of and self-sufficiency in these products, due to their health benefits.**
 - **Urban agriculture:** To help increase the UK's production of fruit and vegetables, we have assumed that **urban areas would supply a significant quantity of these foods.** We have based our assumptions on a recent study which estimated the productive potential of some representative urban areas in the UK, which we then applied across the nation as a whole.¹⁸ The particular scenario we used assumes that around 50% of allotment space, 20% of the cultivated area in gardens and the existing stock of urban fruit trees, would supply us with produce.

Box 3

Livestock enterprises – assumptions and descriptions

With regard to livestock in our modelling, the following enterprises are included:

Dairy: These enterprises typically use robust breeds of dairy cattle. Around a fifth of the calves born are purebred females kept as breeding replacements, with the remaining female and male calves (many of which are dairy beef crosses) reared for meat. A stocking rate of 1.5 animals per hectare is assumed, with 1,000 kilos of supplementary feed (made up of UK-grown cereals, pulses and crop by-products) also given to each cow per year, allowing for an annual milk yield of around 6,000 litres per cow.

Beef and sheep: A mixed beef cattle and sheep enterprise is also assumed, both for temporary and permanent grasslands on grade 1, 2 and 3 land. Animals are reared in a pasture-based system at a stocking density of 1.1 livestock units per hectare, with no use of supplementary feed assumed.

Upland beef and sheep: Due to the more significant environmental constraints found on grade 4 land, a mixed beef and sheep enterprise with a stocking density of 1 livestock unit per hectare is assumed. Young animals are either sold as 'stores' to be fattened on lowland farms or home-finished, with small amounts of supplementary concentrate feed used.

Hill beef and sheep: On grade 5 land, we have assumed the use of beef and sheep enterprises using hardy breeds kept at low stocking densities (0.1 livestock units per hectare). Most calves and lambs are sold at the end of their first summer to be finished on lower land. Within the breeding herds and flocks, a small amount of supplementary feed is assumed.

Pigs: Pigs are reared in free-range outdoor systems where they are able to express their natural behaviours and can obtain a significant percentage of their food from foraging. They are also fed a mix of heat-treated food waste, cereals, pulses and by-products.

Poultry: Laying hens and table poultry are also assumed to be reared in outdoor systems, where they are able to forage and express other natural behaviours. Their main feed consists of a mix of cereals, pulses and other non-human edible arable by-products and foods.

More information on the assumptions underpinning these enterprises are available on request from the author.

Farming on grades 1, 2 and 3a — The best quality agricultural land

Predominant farming system: Mixed arable and livestock

Title: Mixed arable and livestock

Applicable grades of land: 1, 2 and 3a

Area allocated: 3.76 million hectares
(25% of UK farmland)

Typical rotation: 3–4 years cropping,
3 years fertility building

Possible enterprises: arable cropping;
field vegetables; dairy; beef and sheep;
pigs; laying hens; table poultry

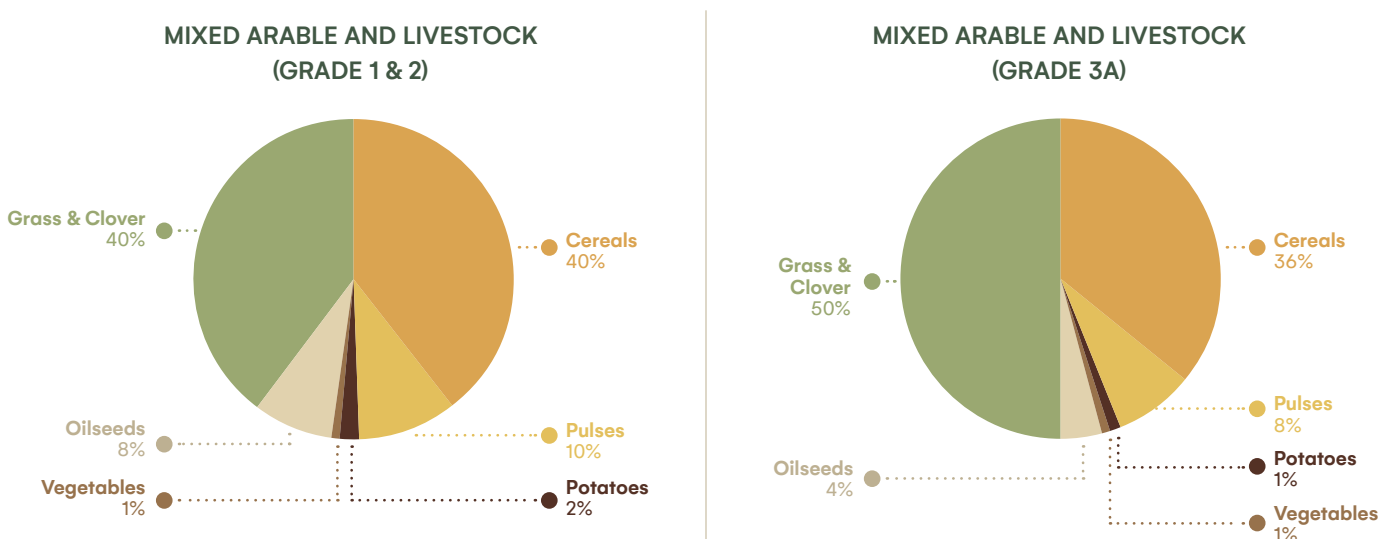
On the UK’s best quality agricultural land, a wide variety of crops can be grown at consistently good yields. To harness the high productive capacity of this land, we designed this mixed cropping and livestock system.

As is shown in the charts below, the majority of productive land within this system would be managed under a rotation where temporary grasslands, normally grazed by livestock, would provide fertility for the ensuing food cropping phase of the rotation, along with the use of livestock manure and overwinter cover crops.

Grazing livestock would be an integral part of this system, due to their ability to convert the temporary grass phase of the rotation into food and income, and the various benefits provided by their grazing and manure.

Livestock enterprises could also include free-range pigs and poultry, converting food waste and other by-products into meat and eggs. However, because they can only obtain a minor percentage of their diet from foraging, these flocks and herds will require supplementation with grains and other by-products from arable cropping.

FIGURE 3.3: THE ALLOCATION OF CROPS TO PRODUCTIVE FARMLAND — MIXED ARABLE AND LIVESTOCK



Alternative 1: Stockless cropping

Title: Stockless cropping

Applicable grades of land: 1, 2 and 3a

Area allocated: 0.66 million hectares
(4% of UK farmland)

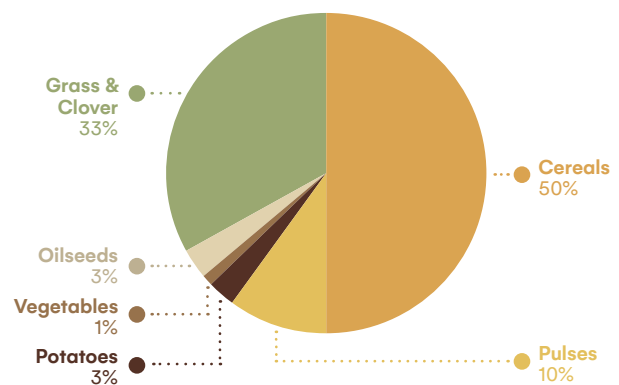
Typical rotation: 4 years cropping,
2 years fertility building

Possible enterprises: arable cropping;
field vegetables

Integrating livestock into crop production systems, though generally of huge benefit for the reasons laid out elsewhere in this report, may not be an approach that all farmers want to adopt. For instance, some farmers and consumers are ethically opposed to the use of livestock in farming systems. For this reason, we have included a stockless system here.

We have allocated this to the best quality farmland, as these are the grades most capable of supporting a system where a third or less of the rotation is given over to fertility building — an important aspect of stockless systems, as the lack of livestock means that the temporary grassland phase of the rotation provides no income, and therefore needs to be kept as short as possible.¹⁹ That said, these are still fundamental in providing the bulk of the fertility for the ensuing years of crop production.

FIGURE 3.4: THE ALLOCATION OF CROPS TO PRODUCTIVE FARMLAND — STOCKLESS CROPPING



Alternative 2: Specialist horticulture (vegetables)

Title: Specialist horticulture (vegetables)

Typical rotation: 3–4 years cropping, 2–3 years fertility building

Applicable grades of land:

1, 2, 3a and 3b

Possible enterprises: field vegetables; protected vegetables; livestock enterprises*; cereals* (*applicable where this system is operated at larger scales)

Area allocated: 0.15 million hectares (1% of UK farmland)

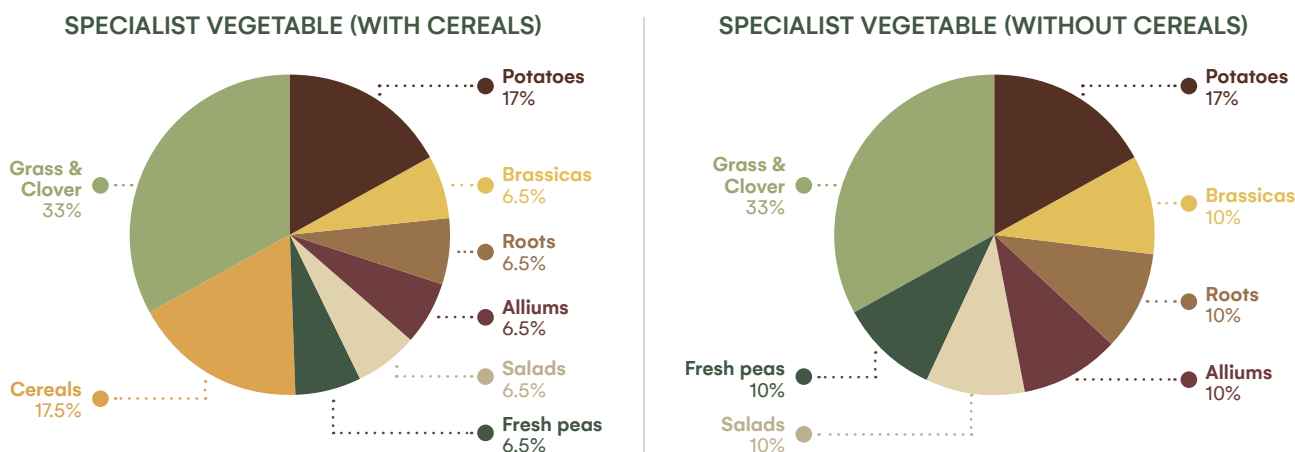
Our modelling includes a significant land area allocated to biologically intensive horticultural production. These highly productive enterprises, which collectively have the capacity to provide a significant percentage of the vegetables needed to feed our population, require high levels of skills and labour.

On land where this system is operated at smaller scales, however, vegetables would be the only cash crop grown (apart from fruit produced from agroforestry) and no livestock integration is assumed, as this can be difficult (though not impossible) at smaller scales. Within this variant of the system ('without cereals' in Figure 3.5), additional fertility is assumed to be provided by green waste composts.

A wide variety of vegetables (including potatoes, brassicas, alliums, roots and salads) would be grown in rotation with short-term, fertility-building grasslands. We have also assumed that on some of the land allocated to this system, where farming is carried out at a large enough scale, a cereal crop would be included at the end of the rotation, and livestock would be grazed on the fertility building grasslands ('with cereals', in Figure 3.5).

Protected cropping (under polytunnels or greenhouses) would also be a common feature of these systems. Although vegetables such as tomatoes, peppers, members of the squash family and salads may constitute the majority area of protected cropping, a wide range of other vegetables can be grown, with the aim of extending the cropping season. In our modelling, protected cropping covers approximately 5% of the productive land allocated to this system.

FIGURE 3.5: THE ALLOCATION OF CROPS TO PRODUCTIVE FARMLAND — SPECIALIST HORTICULTURE (VEGETABLES)



Alternative 3: Specialist horticulture (fruit)

Title: Specialist fruit

Applicable grades of land:
1, 2, 3a and 3b

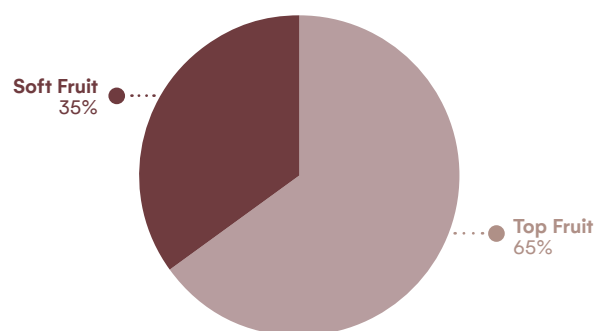
Area allocated: 0.09 million hectares
(0.5% of UK farmland)

Possible enterprises: top fruit; soft fruit;
laying hens*; table poultry* (*applicable
where top fruit, but not soft fruit, is grown)

Typically, these systems produce a combination of top and soft fruits. Top fruits include apples, pears and plums. Soft fruits include strawberries, raspberries and blackcurrants. In top fruit orchards, the understory is often used for laying hen and table poultry production, which benefit from the shelter and insect life provided by the trees in their range.

It should be noted that in practice many specialist horticultural growers combine salad, vegetable and fruit enterprises.

FIGURE 3.6: THE ALLOCATION OF CROPS TO PRODUCTIVE FARMLAND — SPECIALIST HORTICULTURE (FRUIT)



Farming on grade 3b – Land with increased constraints on crop production

Predominant farming system: Mixed livestock and arable

Title: Mixed livestock and arable

Applicable grades of land: 3b

Area allocated: 4.76 million hectares
(32% of UK farmland)

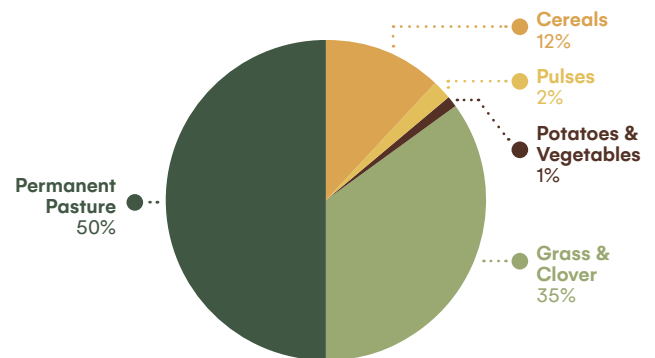
Typical rotation: 50% of productive land under permanent pasture; on other 50%, 2–3 years cropping, 6–7 years fertility building

Possible enterprises: dairy; beef and sheep; arable cropping; field vegetables; pigs; laying hens; table poultry

In comparison with the farming systems assumed on the best quality land, the balance of cropping and livestock in this system shifts, reflecting increased soil, climatic and topographical restrictions, therefore offering a more limited (though still significant) potential for arable production. Typically, half of the farmland in this category would comprise permanent pasture, with the remaining 50% allocated to a crop rotation, most of which would be under temporary grass and clover pastures, followed by a few years of cropping, including cereals, pulses and some field vegetable production.

The permanent pasture and temporary grassland would be managed to provide high quality forage for different grazing livestock enterprises, including dairy, beef and sheep, with some pastured poultry and free-range pigs.

FIGURE 3.7: THE ALLOCATION OF CROPS TO PRODUCTIVE FARMLAND — MIXED LIVESTOCK AND ARABLE



Farming on grade 4 — Land largely unsuitable for crop production but which can support productive grasslands

Predominant farming system: Grazing livestock

Title: Grazing livestock

Area allocated: 2.24 million hectares (15% of UK farmland)

Applicable grades of land: 4

Possible enterprises: upland beef and sheep; dairy

On grade 4 land, greater environmental constraints largely exclude arable cropping. However, this land is generally capable of supporting good levels of grass growth, and so can be used for productive systems of grazing livestock. The main enterprise assumed in this system is the rearing of beef cattle and sheep, though we have also allocated some dairy production within this grade. Because of the greater environmental constraints, livestock are kept at lower stocking densities than on better grades of land. However, with holistic grazing techniques, good levels of pasture

productivity can be maintained across most of this land, through the reseeding of pastures with nutritious species of forage plants.

In some instances, small-scale intensive horticulture or arable cropping could be practiced on this grade of land. However, with some exceptions, commercial production of arable crops for human consumption is usually both impractical and uneconomic, and so has not been assumed here.

Farming on grade 5 — Land limited to extensive, rough grazing

Predominant farming system: Extensive grazing

Title: Extensive grazing

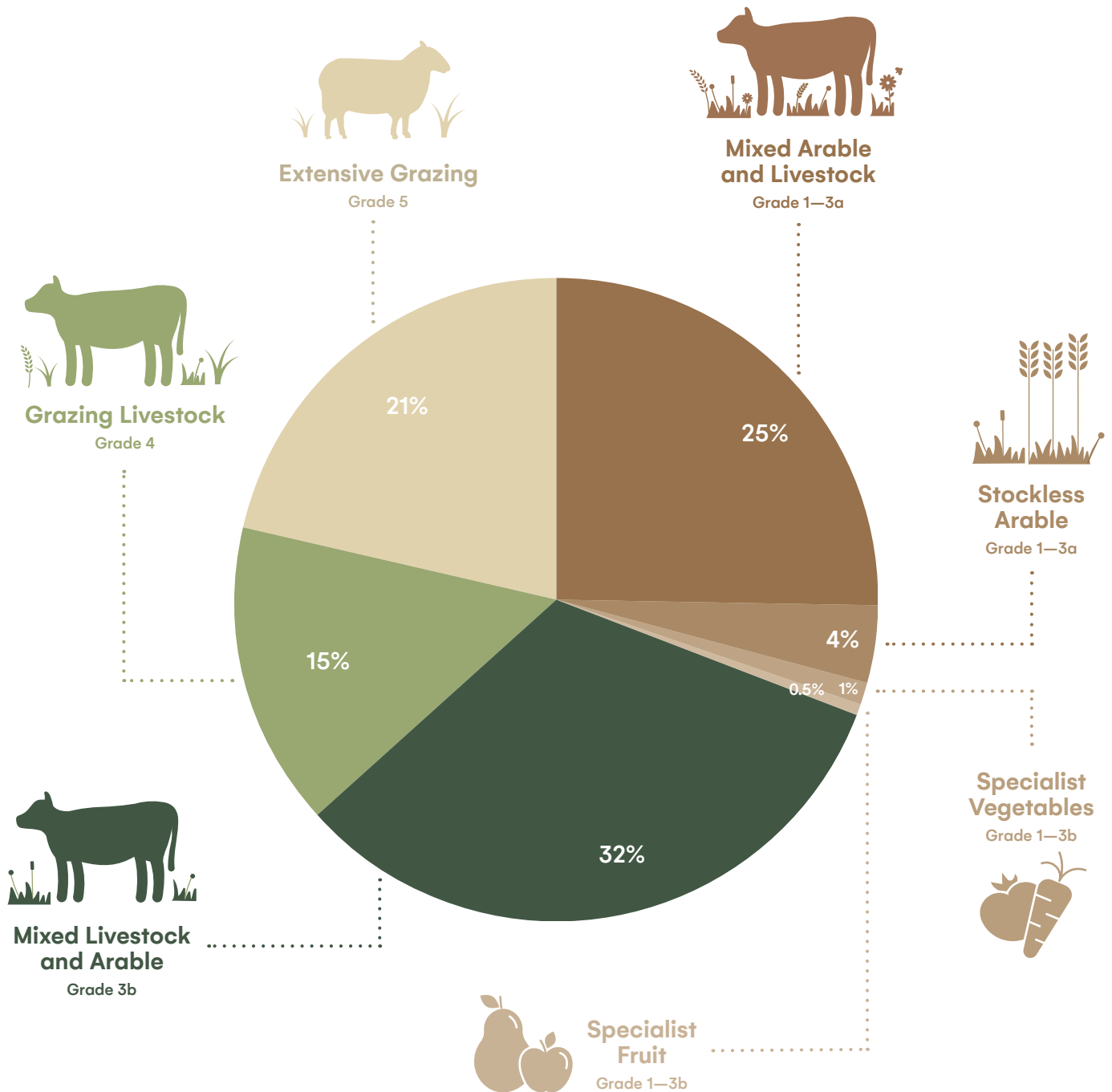
Applicable grades of land: 5

Area allocated: 3.14 million hectares (21% of UK farmland)

Possible enterprises: hill beef and sheep

The extensive areas of native grass and moorlands which cover much of the UK's uplands require sensitive management, with low stocking rates of hill breeds of sheep and beef cattle required to maintain biodiversity without causing overgrazing. Some improved pasture is also allocated to this system, to allow for winter feed production and higher quality grazing at key points of the animals' breeding cycle. All of the lambs and calves produced for meat within this system are assumed to be sold at the end of their first summer, to be fattened and slaughtered on more productive lowland farms.

FIGURE 3.8: HOW THE UK'S AGRICULTURAL LAND WAS ALLOCATED TO DIFFERENT FARMING SYSTEMS



Step 3: Calculate food productivity of a sustainably farmed UK

Having allocated the UK's agricultural area to the farming systems modelled in this study, the next step was to calculate how much food these systems, and the nation as a whole, would produce.

As part of our decision to model biologically based farming systems, we decided to use data from the organic sector. This is because it is the closest system to the approach modelled in this study, for which there is also plenty of published data on productivity.

Lower yields are almost inevitable in the kinds of sustainable farming systems modelled in this study. However, there is thought to be considerable potential to increase these through a number of strategies.²⁰ **Therefore, we have assumed a 20% increase in crop yields in our modelling.**

One of these strategies includes intercropping, where two or more different crops are grown alongside each other on the same piece of land. This is a practice which can increase the total yield of food per hectare, with one review of intercropping trials finding that total yield per hectare increased by 22% on average.²¹ Greatly increasing the amount of research into the development of crop breeds suitable for agroecological systems is another key strategy, with almost all commercial crop breeding work, until recently, focused on conventional, high input systems.²²

Another area where there is significant scope for increasing the productivity of biologically based farming systems, would be through the recycling of sewage and wastewater. Sewage sludge is currently not permitted in organic food production in the UK, due to potential contamination from a wide range of medicines, chemicals used in domestic households, heavy metals, plastics and other contaminants.²³ However, the way we currently treat human waste results in the loss of many nutrients valuable for agriculture, including nitrogen, phosphorus and potassium, and so applying the principles of the circular economy in relation to human waste has long been a key objective.²⁴

Progress has already been made in the development of treatment and nutrient extraction technologies to remove these risks, and sewage sludge is now used on some conventional farms in the UK. With additional work in this area, however, it is likely that with time, an even greater proportion of the nutrients lost in sewage and wastewater can be recovered, and this could represent a very significant additional source of fertility for use in sustainable farming systems.²⁵

Step 4: Assess the impact on individual diets and nutrition

The final step in our methodology was to investigate what impact any changes in food production might have on our individual diets and national self-sufficiency.

To do this, we first of all calculated the amount of UK-produced food that would be available for human consumption, by adjusting the production figures to take account of the amount that would be ‘lost’ through processing (e.g., through cheesemaking and milling) and used for other purposes such as livestock feed.

We then divided the total amount of UK-produced food available for human consumption, by the total projected population of the UK in 10 years time (70 million),²⁶ to reflect the fact that we will not be able to transition to sustainable farming systems overnight. This then provided us with figures on how much food, per person per day, would be available from UK production.

To enable a comparison with the present day, we also carried out these calculations for current UK production.

Next, we assessed what contribution sustainable farming systems would make towards our daily nutritional needs. To do this, we calculated how many calories and how much protein, fat and carbohydrates would be available for consumption, per person, from sustainable UK production, using official data on the nutrient composition of different foods.²⁷ We then compared this against the European Food Safety Authority’s (EFSA) recommended intake of calories, protein, fat and carbohydrates for an average European adult.²⁸

We also calculated how many calories and macronutrients would be available for consumption from current UK production. These figures, along with a calculation of the current total demand for calories and macronutrients,²⁹ allowed us to compare how the UK’s self-sufficiency would change following the transition to sustainable farming systems, assuming a future change in diet to EFSA’s recommended levels of intake. This enabled us to assess whether the UK would need to import more or less food than at present.

Balcaskie Estate Fife

Situated in the East Neuk of Fife, Balcaskie Estate is an organic mixed livestock and arable farm. Seven years ago, in an attempt to improve their financial and environmental sustainability, they converted the farm to organic. Today, most of the farm is under pasture, grazed by cattle and sheep, but 200 hectares is cropped under a rotation, with five years of diverse, fertility-building herbal leys grazed by livestock, followed by two years of cereal and bean production, grown for human consumption.

Since conversion, the farm has moved to a 100% pasture-fed approach, using native breeds of cattle and sheep and mob grazing systems, which has eliminated the need for bought-in feeds, significantly reduced costs and improved biodiversity. The farm has also seen an improvement in soil health, increased employment, and a reduction in energy use, with around 50% of energy now provided from heat and solar produced on-farm.

Size: 1300 hectares

- 200 hectares under cropping, under a seven-year rotation consisting of:
 - five years of fertility-building leys, grazed by beef cattle and sheep
 - two years of cereal and bean cropping
- 1000 hectares of grassland

Food output

- **Beef:** 80 tonnes
- **Lamb:** 20 tonnes
- **Cereals and pulses:** 1000 tonnes

Number of employees

- Eight







CHAPTER FOUR

Results — How land use and food production would change

Chapter 4 — Results

Summary

A UK-wide introduction of sustainable and regenerative farming systems would have significant impacts on land use and food production.

The transition to sustainable farming practices would transform the farmed landscape, with a general move to mixed farming resulting in the reintroduction of grassland and grazing livestock production in arable areas and cropping in some regions which are currently dominated by grassland. We have also factored in an increase in tree cover and land used for nature, across the nation as a whole.

As a result of these land use changes and the transition to sustainable farming practices which we modelled, grain output would fall significantly, as would production of poultry, pork, and to a lesser extent, dairy. Conversely, fruit, vegetable and pulse production would increase. Beef and lamb production would remain at levels similar to today, but the production systems would be less intensive, with animals fed much less grain.

IMPACTS ON LAND USE

- **Total land area under agricultural allocation:** Agricultural activity currently makes up 72% of the total land area of the UK (17.5 million hectares out of a total 24.2 million hectares). Under our modelling this would decrease to 62% (15.1 million hectares).
- **Cropland:** Land currently under continuous arable production (cereals, oilseeds and pulses) would see the

reintroduction of mixed farming, with crop rotations (including temporary grasslands) necessary to build soil fertility. In these areas (typically in the east of the UK), this transition would result in a reduction in the area of land growing crops and an increase in temporary pasture. In the majority of cases, these grasslands would be grazed by livestock.

This would result in a significantly smaller area of land dedicated to growing cereals (-25%). The area used to grow oilseeds and sugar beet would also fall. Conversely, the area under pulses would increase from 0.2 million hectares to approximately half a million hectares (+131%), reflecting the importance of peas and beans as nitrogen-fixing break crops that provide an important source of protein for humans and livestock.

The land allocated to growing vegetables and fruit would also increase overall (+52%), due to the decision in the model to increase the production of these foods for improved human health. There would be an additional contribution from urban and peri-urban areas as well as fruit production from agroforestry.

- **Grasslands:** We also modelled a significant reduction in the area under permanent pasture and rough grazing (-31%) due to an increase in woodland cover and land dedicated to nature.

However, there would be an increase in the area under temporary grassland (+219%), which would form part of mixed, rotational farming systems.

- **Woodland and land for nature restoration:** In the scenario we modelled, woodland cover would increase by close to a million hectares (+28%) and many more trees would be integrated into the farmed landscape through a major increase in agroforestry. There would also be more land for nature across the nation as a whole.

IMPACTS ON FOOD PRODUCTION

- **Arable crops:** Cereal production would halve (from 23.2 million to 10.7 million tonnes) due to a reduction in the area of land for cereals and the elimination of chemical fertilisers and pesticides. Pulse production, however, would increase significantly (from 0.9 million to 1.9 million tonnes) due to their importance in sustainable crop rotations and for human and livestock nutrition.
- **Vegetables and fruit:** Vegetable and fruit production would double, with a diversity of crops being grown much more widely across the nation.
- **Grain-fed livestock:** Pork (-76%), chicken (-73%) and egg production (-47%) would see significant decreases

in production, mainly due to the reduction in the amount of cereals available to feed to livestock and the elimination of imported protein feeds (such as soya).

- **Grazing livestock:** Beef production would only fall slightly (-3%), while lamb production would remain stable, due to the important role that grazing livestock play in rotational, mixed farming systems. Dairy production would fall (-25%) due to a decrease in milk yield resulting from a transition to pasture-based systems and a reduction in the amount of grain being fed.

If the UK were farmed according to the guiding principles informing this report, there would be significant changes to the way we use land and in the production of certain food groups. The first half of this chapter sets out how land use would change, and the second outlines the resulting impacts on food production. What these changes might mean for the diet of UK citizens, as well as what imports may be required, is explored in chapter 5.

MIXED FARMING AND GRASSLANDS

One of the most notable changes in land use in our modelling, is the return to mixed farming across a large part of the UK's farmed area.

This transition would have a transformational impact on our countryside, marking the end of a seventy-year chapter in agricultural history, during which food production has become increasingly specialised, with arable cropping concentrated on the best soils (predominantly in the eastern counties), and livestock systems on the grasslands in the north and west of Britain. This siloed approach to food production will give way, where possible, to **a diversity of integrated livestock and crop production systems on mixed farms across the UK. This would mean a move away from extractive farming methods to more diverse systems based on biological principles, in line with the circular economy.**

Such a landscape-scale transformation would have significant impacts on the nature and use of our grasslands. The area devoted to permanent pasture would decline (from 6.2 to 3.6 million hectares). This is partly due to an increase in tree cover and the conversion of some improved grassland to rough grazing, as well as the widespread transition to mixed, rotational farming, which would see some permanent pasture converted to land that

would grow arable crops within a long-term, grass-dominated rotation. Because of this transition, the area of temporary grassland would increase, especially in the eastern counties, where after decades of continuous arable farming, temporary pastures grazed by livestock would be reintroduced on a large scale (increasing, in total from a current area of 1.2 million hectares to around 3.7 million hectares). Of course, permanent pastures designated for their biodiversity value, including the conservation of specific species, would not be converted.

Typically, all grasslands would become more biodiverse, due to a combination of sensitive grazing management, the phasing out of nitrogen fertiliser and herbicides and the use of species-rich seed mixtures on temporary pasture.¹

Managed correctly, these grasslands (which would comprise three-quarters of the UK's farmed area, compared with the current two-thirds) also have the potential to sequester significant amounts of carbon. The greatest potential exists where temporary grasslands are reintroduced into arable areas, as carbon levels in cropland soils are, generally speaking, currently very low due to decades of continuous cultivation (38% are significantly degraded across England and Wales).² However, with appropriately managed rotational grazing, there is potential for further sequestration on existing grasslands too.³ In combination, this drawdown of CO₂ from the atmosphere

could have a significant impact on slowing climate change (see Box 4 for information on carbon sequestration).

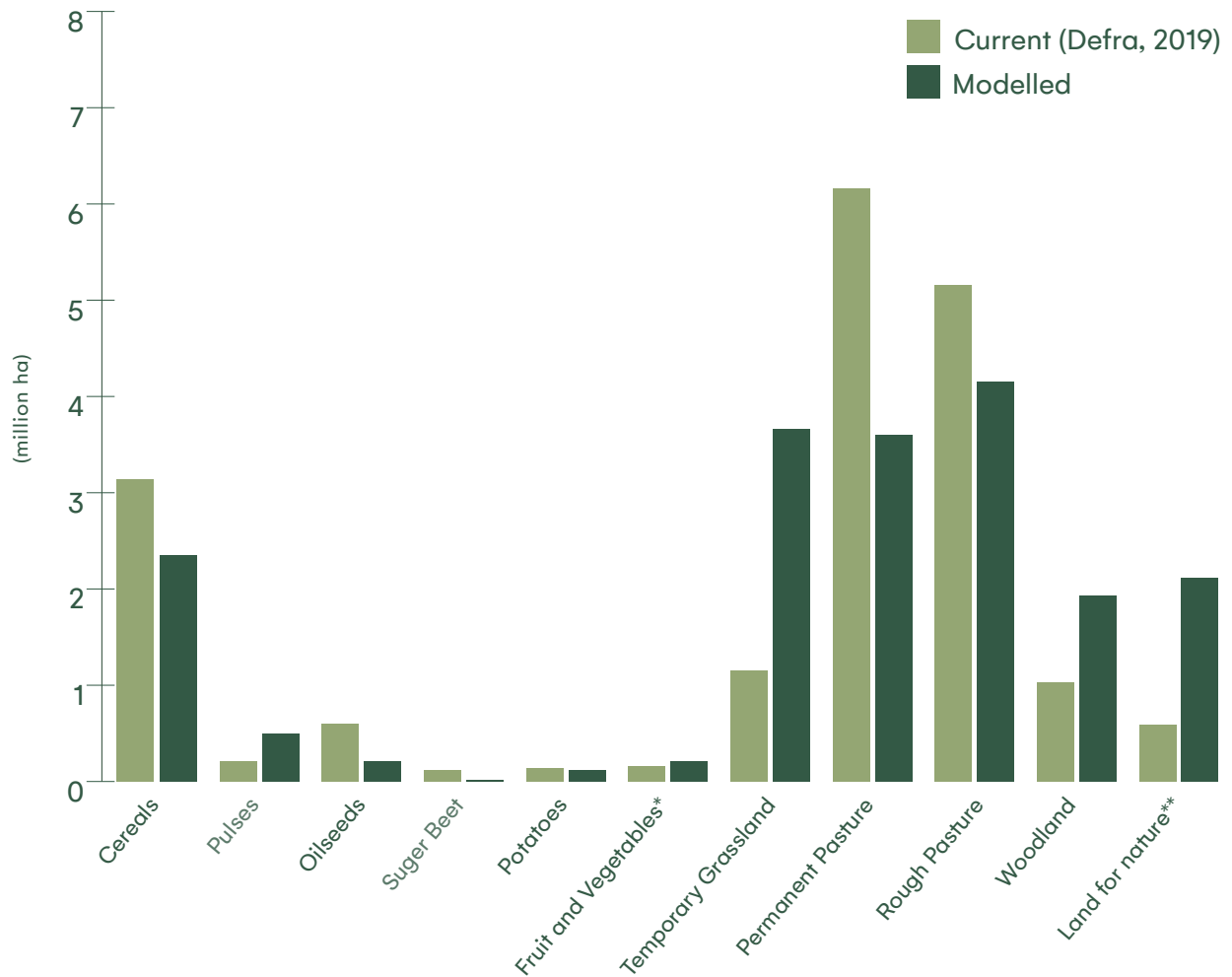
Concerns about the negative impacts of converting some permanent pasture to land for mixed farming should be seen in the context of the net carbon outcomes of a UK-wide agricultural transition. Environmental and climate impacts are not something that we measured in this study. However, the loss of soil carbon from land converted from permanent pasture to arable would be somewhat minimised

because most of this converted pasture would likely consist of grade 3b land that would go into a long-term rotation dominated by grass, with only a few years of arable cropping.⁴ In addition, the major increases in carbon sequestration resulting from the reintroduction of temporary grasslands in existing arable areas, the increase in woodland cover and the widespread uptake of agroforestry, amongst other practices, would likely mean there would be a major net gain in carbon storage (see box on carbon sequestration below).



Impacts on land use

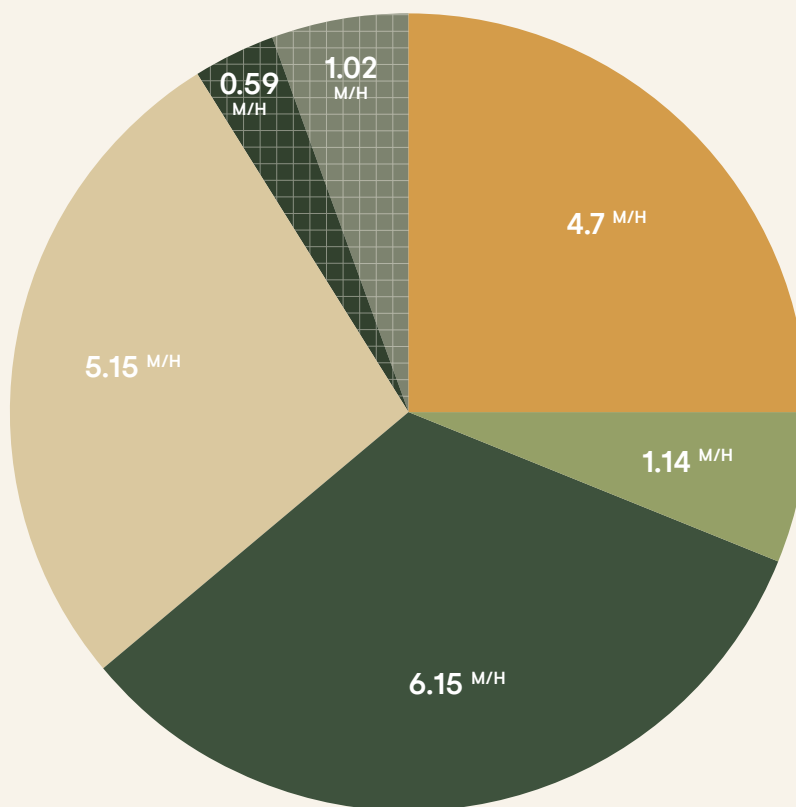
FIGURE 4.1: CHANGES IN UK AGRICULTURAL LAND USE FOLLOWING THE TRANSITION TO SUSTAINABLE FARMING



* Does not include land under urban horticulture

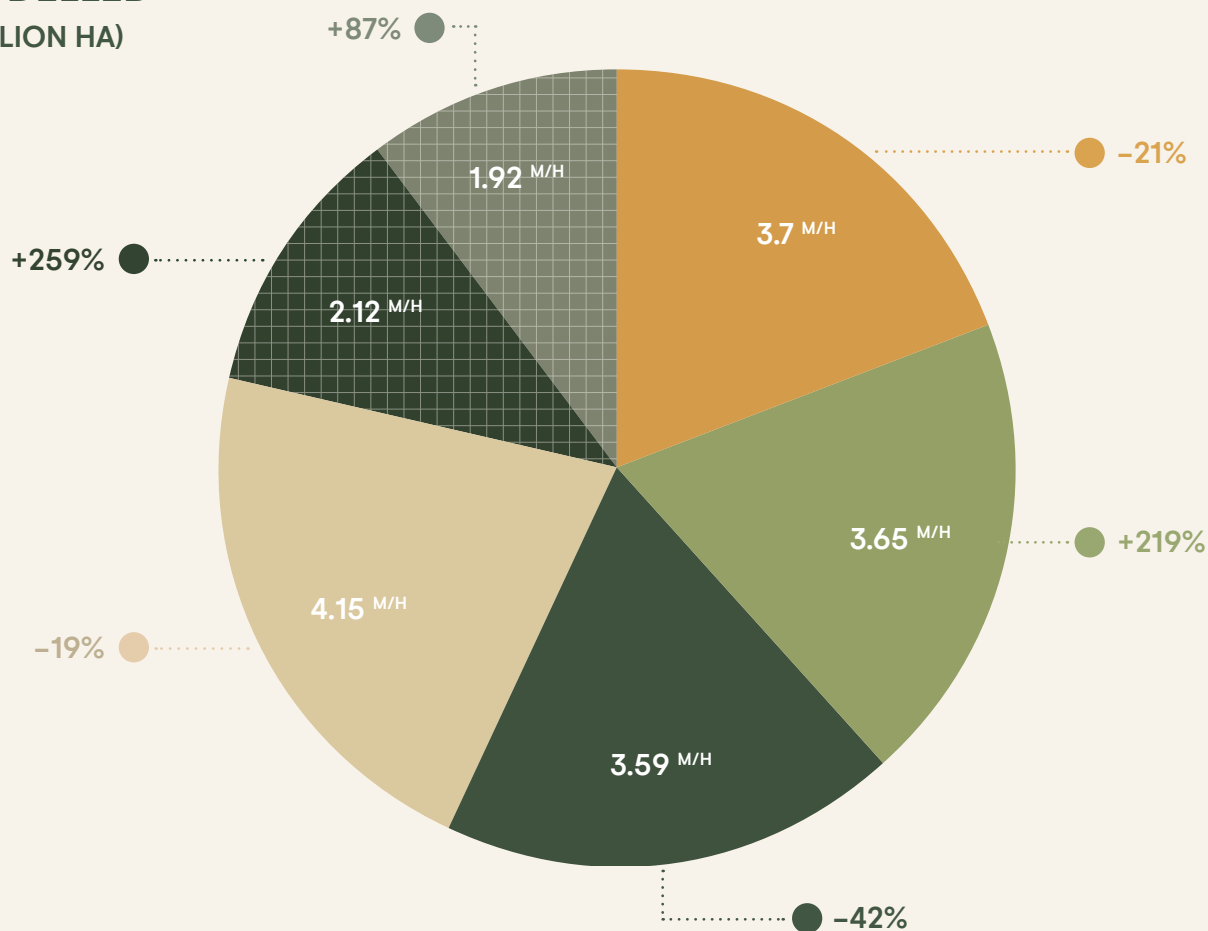
** For current, includes uncropped arable and other non-agricultural land

CURRENT
(Defra, 2019)
(MILLION HA)



- Crops
- Temporary Grassland
- Permanent Pasture
- Rough Grazing
- Land for Nature*
- Woodland

MODELLED
(MILLION HA)



*For current, includes uncropped arable and other non-agricultural land



Potential impacts on biodiversity and carbon sequestration

Sustainable and nature-friendly farming systems are characterised by the minimal use of chemical inputs, and diverse, complex landscapes which contain an abundance of semi-natural habitats.⁵ For this reason, **the approach to farming modelled in this report would almost certainly result in a more biodiverse landscape than today**, given the following assumptions:

- The elimination of pesticides and chemical fertilisers⁶
- A wide diversity of crops grown in rotation⁷
- The use of a diversity of forage legumes and other species in temporary grassland⁸
- The allocation of 10% of the nation's croppable area to on-farm natural habitats⁹
- A major increase in hedgerow and agroforestry cover¹⁰
- The transition of around 2 million hectares of land, mainly from agricultural use, to woodland and rewilding¹¹
- Appropriate stocking densities of sheep and cattle, grazed in ways that benefit biodiversity¹²

The land use and farming practices modelled in this study would also likely deliver major increases in carbon sequestration. These include:

- A significant increase in the area of arable land under temporary grasslands¹³
- Major increases in woodland and agroforestry cover¹⁴
- Increased hedgerow cover¹⁵
- Increased land for nature and rewilding¹⁶
- Changes in grazing management¹⁷

These major gains may be lessened by the loss of soil carbon when converting some permanent pasture to arable land. However, reductions in greenhouse gas emissions (which are touched on in the box on 'Livestock and climate change') also need factoring in, as does the delivery of other environmental and social benefits — all of which emphasises the need for an internationally common framework for measuring whole farm sustainability (see Chapter 6 for specific recommendations).

It is outside the scope of this report to say what the net climate impact of these changes would be. However, a recent study carried out by the French research institute IDDRI, estimated that a UK-wide transition to agroecology would increase soil carbon sequestration by a third compared with what it is today.¹⁸ While their modelling assumptions differ somewhat from ours, their findings do point towards the kind of carbon gains which might be expected from the approach modelled in this study.

THE BALANCE OF CROP PRODUCTION

Although the area of arable land (i.e., land used for cropping and temporary grasslands) would increase by 25% overall, the actual area used for growing crops in any one year would decline, because fertility-building temporary grasslands would form a major part of the rotation. This approach would replace the need for chemical fertilisers, with temporary grasslands (including grass and clover mixes, as well as diverse herbal leys, often grazed by livestock) naturally building soil fertility, ready for the arable phase of the rotation.

The move to more mixed farming would also change the balance of crops grown. This is informed by the need to add more diversity to our farming systems, and to focus more on foods beneficial for human health. For instance, in contrast to the specialised monocultures of crops such as wheat, barley and oilseed rape that currently dominate much of the arable landscape, we have reintroduced a wider range of crops, such as other cereals (like oats and rye), pulses (peas and beans), field vegetables and fruit.

The area under pulses would increase from 0.2 million hectares to approximately half a million hectares (+131%), reflecting the importance of peas and beans as nitrogen-fixing break crops that provide a valuable source of protein for humans and livestock.¹⁹ **The area of agricultural land under fruit and vegetable production would also rise, from**

0.16 million hectares to 0.21 million hectares (+52%), due to the decision in the model to try and increase the production of these foods for reasons of human health. It should be noted that this area only refers to the fruit and vegetables grown in fields in rural areas. By including the area under urban horticulture (which is not included in our land use figures) as well as top fruit production in some agroforestry systems, this increase would be more significant.

Other crops, however, would see a decline. The area used to grow cereals would shrink from 3.1 million hectares to 2.4 million hectares (-25%), with a major reduction in the area under wheat and barley only being partially offset by an increase in the area under oats and rye. The area under oilseeds would decline even further, from roughly 0.6 million hectares to 0.2 million hectares (-65%), while sugar beet production would fall from 0.1 million hectares to 15,000 hectares (-88%). These changes are partly due to a return to mixed farming within the model, which would require the production of a greater diversity of crops than today, as well as our decision to reduce the amount of land used for growing sugar beet and oilseed rape, as these crops are difficult to grow without pesticides, which we assume no use of in this study. It is worth noting, however, that there are currently some successful trials into organic oilseed rape production in the UK, and so it may well be the case that in the future, a greater area of land could be given over to this crop than we assume here.²⁰

LAND FOR NATURE

While we assume the reversion of some improved pasture to semi-natural rough grazing, our decision to increase woodland cover, and allocate 1 million hectares of grade 5 land for nature restoration, means that the total area of rough pasture would decline by 19%. However, a significant percentage of the grade 5 land used for nature restoration would remain as grassland and moorland, due to the value of these open ground habitats for nature, and this means, in reality, the reduction in the total area under rough pasture would be less than 19%.

This would contribute to the huge increase (of around 1.5 million hectares) in the area of land used for nature and other ecosystem services. Around two-thirds of this would consist of upland areas

removed from agricultural production, while the other third is attributed to the improved integration of biodiversity-enhancing features (such as hedges, wildflower meadows, beetle banks, wetlands and woods) into agricultural land. The latter comes from the assumption in our model that 10% of land suitable for cropping would not be used for agricultural production.

The final notable change in land use is the **major increase in woodland cover.** This would mean that the area of the UK under forest and woodland would increase from roughly 13% of the country to 17% — in line with the recommendations of the Climate Change Committee.²¹ An expansion in tree cover would also be delivered through the introduction of agroforestry systems across 10% of the UK's farmed area, resulting in a much greater integration of trees, crops and livestock than at present.



Box 5

Livestock and climate change

As outlined in Chapter 2, we know that livestock can deliver a range of key social and environmental benefits, provided they are reared in a sustainable manner. Grazing livestock are particularly good at converting grass and other inedible feeds into nutrient dense food, helping to build and maintain soil health and fertility, and grazing in ways that benefit biodiversity. What might rearing livestock in this manner mean for the climate, though?

Whilst this isn't something we attempted to measure in this study, the impact on climate of this approach to livestock production is an area that many others are researching, and there is good reason to believe that such practices could play a positive role in tackling climate change.

Firstly, **grazing livestock have a key role to play in eliminating the use of nitrogen fertilisers, one of the main sources of agricultural emissions in the UK.** This is because clover and other forage legumes naturally convert inert atmospheric nitrogen into the reactive nitrogen compounds that plants need to grow. In most cases, therefore, the only way to ensure a highly productive food system without the use of nitrogen fertiliser, is through the use of crop rotations which contain a fertility-building (grass and forage legume) phase, which then, generally, needs to be grazed by livestock to ensure the overall productivity and profitability of the system.²² In other words, from an economic and food security perspective, grazing livestock make it possible to have a significant proportion of the crop rotation under grass, which then eliminates the need for nitrogen fertiliser.

Emissions of nitrous oxide (a powerful greenhouse gas) could be reduced even further by moving to lower stocking densities and well-managed grazing systems with clover-rich pastures,²³ and through better management of manure.²⁴ Moving away from intensive livestock production, including a major reduction in pig and poultry numbers, would also mean considerably less manure than today, resulting in fewer emissions of nitrous oxide and methane, while less intensive feeding regimes could reduce methane emissions per cow.

As a result of ending intensive livestock production, imported protein feeds like soya would no longer be required. This would reduce the high levels of carbon dioxide released as a result of the overseas land use change associated with its production, including the destruction of rainforest and other natural habitats.²⁵

And, as the biodiversity and carbon sequestration box explains, the introduction of fertility-building grasslands onto arable land (which, as discussed, is often only feasible through the use of grazing livestock) and the integration of trees and livestock through agroforestry systems, would likely deliver major increases in carbon sequestration, although more research is needed to quantify this.

The outstanding issue in the public debate about the sustainability of livestock production is methane. It is true that sheep and cattle are a major source of methane emissions, and because their numbers are maintained at roughly current levels in our



model, this could be seen as a problem. However, because methane is a short-lived greenhouse gas that breaks down in the atmosphere after approximately twelve years, it only causes further increases in warming if emissions are rising, which happens when ruminant numbers are increasing. This is important because, whilst we will need to reduce methane emissions from livestock to stay under 1.5 degrees centigrade of warming, we will not have to eliminate methane emissions entirely. This is unlike carbon dioxide emissions, which must be reduced to net-zero as soon as possible, as these persist in the atmosphere and therefore will continue to accumulate for as long as emissions are occurring.²⁶

There are various strategies being developed which may allow us to achieve the reductions in methane emissions required to meet our climate goals by 2050, without major cuts to the number

of grazing livestock in this country. One of these is the use of feed additives which reduce the amount of methane an animal produces.²⁷ There are also attempts to develop a vaccine that could achieve similar results.²⁸ Finally, research has shown that some animals naturally produce significantly less methane than others. As such, selective breeding from these animals appears to offer major potential to cut methane emissions.²⁹

IDDRI's modelling of a UK-wide transition to agroecology examined a similar approach to this study (albeit with more of a reduction in ruminant numbers) and found that agricultural emissions would fall by 38%.³⁰ It's clear, therefore, that farming in harmony with nature can play a key role in the fight against climate change, and grazing livestock are an important part of this.

Impacts on food production

Based on our model's calculations and assumptions, **significantly fewer intensively reared pigs and poultry, and cereals for animal consumption, would be produced**, freeing up land for other crops and **allowing the UK to more than double its production of fruit, vegetables and pulses** for human consumption.

Production of milk would fall by a quarter, but beef and lamb would continue to be produced at levels similar to today. This is due to the key role grazing livestock can play in building soil fertility, reducing the

need for chemical inputs, converting grass and other forage into nutrient dense food and supporting biodiversity. Because of this, grass-fed animals and their meat and milk would be a key part of a sustainable farming system.

The table and graphs below illustrate the volumes of food that would be produced if the UK transitioned to the approach to sustainable farming modelled in this study, compared to the volume of food the UK currently produces.



FIGURE 4.2: HOW FOOD PRODUCTION WOULD CHANGE FOLLOWING A TRANSITION TO SUSTAINABLE FARMING

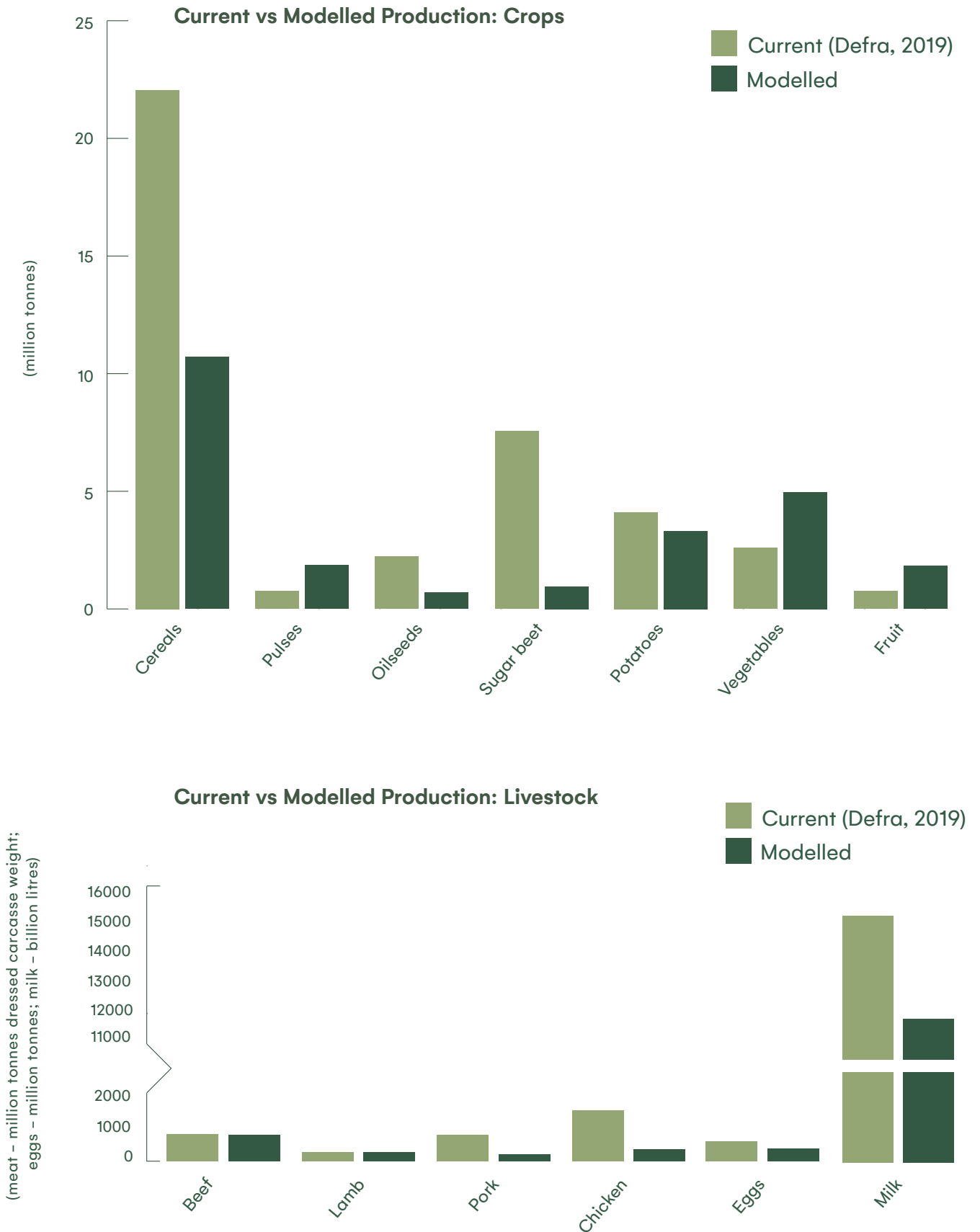


TABLE 4.1: CHANGES IN PRODUCTION (CROPS)

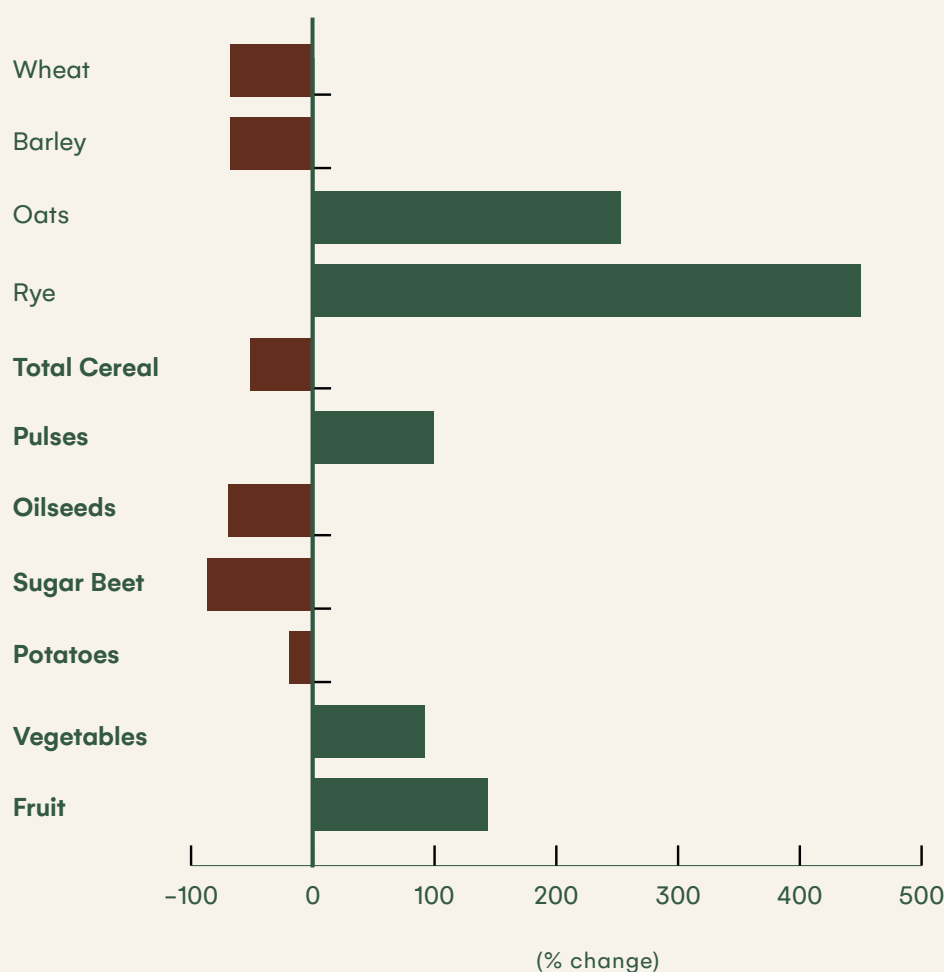
FOOD TYPE	CURRENT PRODUCTION*	MODELLED PRODUCTION	% CHANGE
Cereals	23.2	10.709	-54%
Pulses	0.931	1.851	+99%
Oilseeds	2.016	0.696	-65%
Sugar beet	7.99	0.952	-88%
Potatoes	4.109	3.311	-19%
Vegetables	2.53	4.968	+96%
Fruit	0.721	1.824	+153%

TABLE 4.2: CHANGES IN PRODUCTION (LIVESTOCK)

FOOD TYPE	CURRENT PRODUCTION*	MODELLED PRODUCTION	% CHANGE
Beef	0.907	0.88	-3%
Lamb	0.309	0.309	0%
Pork	0.893	0.217	-76%
Chicken	1.632	0.436	-73%
Eggs	0.837	0.447	-47%
Milk (billion litres)	15.072	11.316	-25%

*Defra (2019)

FIGURE 4.3: CHANGES IN PRODUCTION (CEREALS, OILSEEDS AND SUGAR BEET)



In our model, overall cereal production would fall by around 50%.

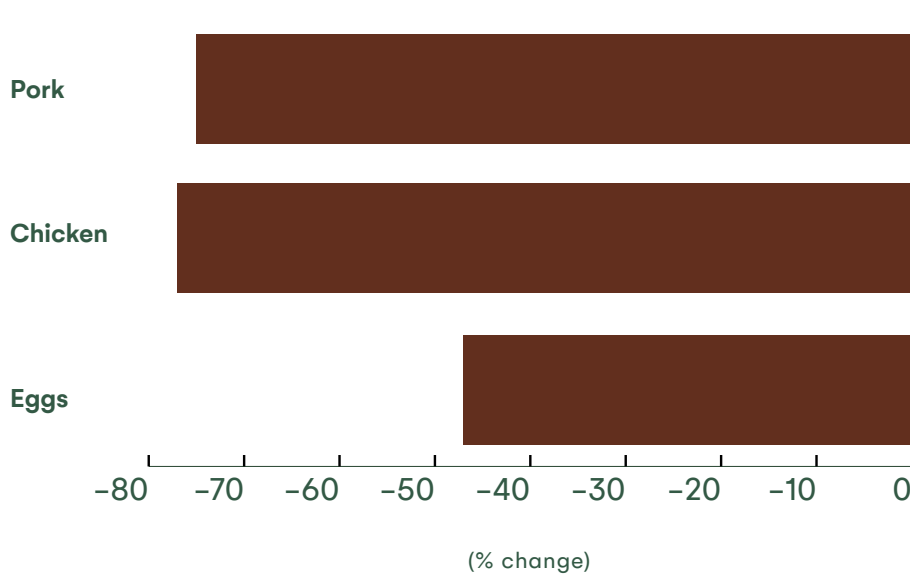
Because we have assumed a transition to more mixed farming systems, growing a greater diversity of crops, less land has been allocated for cereal production. As a result of this, alongside the fall in yields which would occur because of the elimination of chemical fertiliser and pesticide use, wheat and barley production would fall by over two-thirds.

UK cereal production is currently dominated by wheat and barley, however we have modelled a significant increase in the production of oats and rye, as these are both well-suited to low input systems,

and increasing these crops would improve diversity in rotations. Oats could also become a more important ingredient in pig and poultry feed in the form of ‘naked oats’ — a variety which has an excellent nutrient profile that can make it a viable replacement for other cereals.³¹

Oil seed rape (OSR) and sugar beet production would fall significantly, by close to 70% and 90% respectively, due to the prioritisation in the model of what we feel are more important crops (fruit, vegetables, pulses and cereals); the need to reduce sugar in diets (relevant to sugar beet); the damage to soil health often associated with sugar beet production;³² and the fact that both crops are heavily reliant on pesticides.³³

FIGURE 4.4: CHANGES IN PRODUCTION (PORK, POULTRY AND EGGS)



The production of chicken and pork would fall significantly — by about 75% each — largely because of the reduction in cereal production. Cereals are a key ingredient in pig and poultry feed, and the major increase in cereal production over the past 70 years has been fundamental to the dramatic rise seen in the production and consumption of chicken, in particular. The modelled reduction in cereal production would, however, reverse this trend, as there would no longer be enough cereals available to sustain current pig and poultry numbers. This would increase the overall efficiency of the food system, since feeding significant quantities of cereals to livestock represents a wasteful use of food, as animals are highly inefficient at converting human-edible crops into meat, milk and eggs.

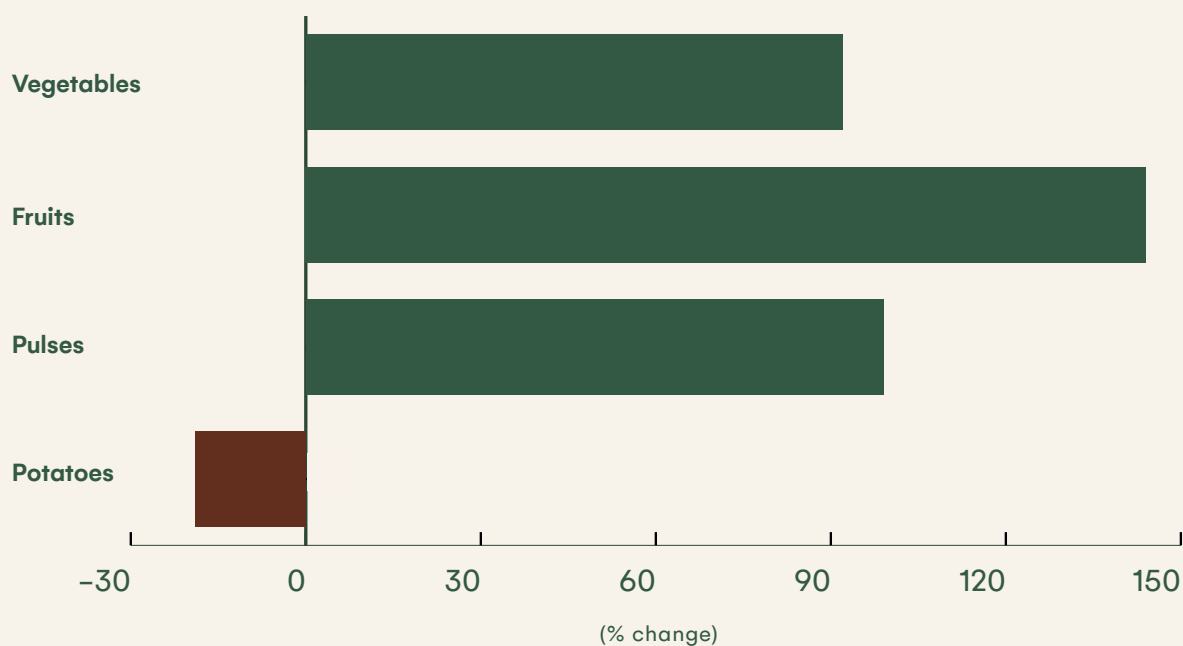
For these reasons, the amount of cereals fed to livestock would fall dramatically. **Currently, about half of the cereals grown in the UK are fed to livestock,³⁴ but this would fall to less than 20%.** The elimination of imported protein feeds

would also have an impact on pork and chicken production, as soya bean meal, in particular, is currently a key ingredient in their diets.

Egg production is also reduced for the same reasons as pork and poultry production, but at a lower level than chicken, due to the prioritisation of egg production over poultry meat production. This is for a number of reasons: not only is it more efficient to produce eggs than chicken, but the hen can also be slaughtered for meat at the end of her productive life, and eggs are an important source of protein for consumers, particularly vegetarians, and are used in a wide variety of foods.³⁵

We have assumed that pigs and chickens would be farmed according to the principles and characteristics informing this report — as part of free-range systems, where the animals consume a combination of heat-treated food waste, cereals, pulses and forage.

FIGURE 4.5: CHANGES IN PRODUCTION (FRUIT, VEGETABLES AND PULSES)



With less land used to grow cereals, sugar beet and oilseed rape, we have chosen to allocate more land to healthy food crops, helping to double the production of vegetables, fruits and pulses.

We have prioritised the production of pulses in our model as they are able to fix nitrogen in soils naturally and break pest, weed and disease cycles when included as part of a crop rotation, helping to reduce the use of synthetic fertilisers and pesticides. Pulses also provide high levels of protein for human consumption, as well as for livestock.

The major increase in fruit and vegetable production was assumed because of their importance in healthy diets, and because of the need to improve on the UK's low levels of self-sufficiency of these crops, which currently sits at around 50% for vegetables and a mere 15% for fruit.³⁶ Most fruit and vegetable production would take place on agricultural land, (though much more widely than at present), in specialist production systems, as more minor parts of mixed systems, and in the case of top fruit (such as apples, pears, plums and cherries) from a portion of the area under

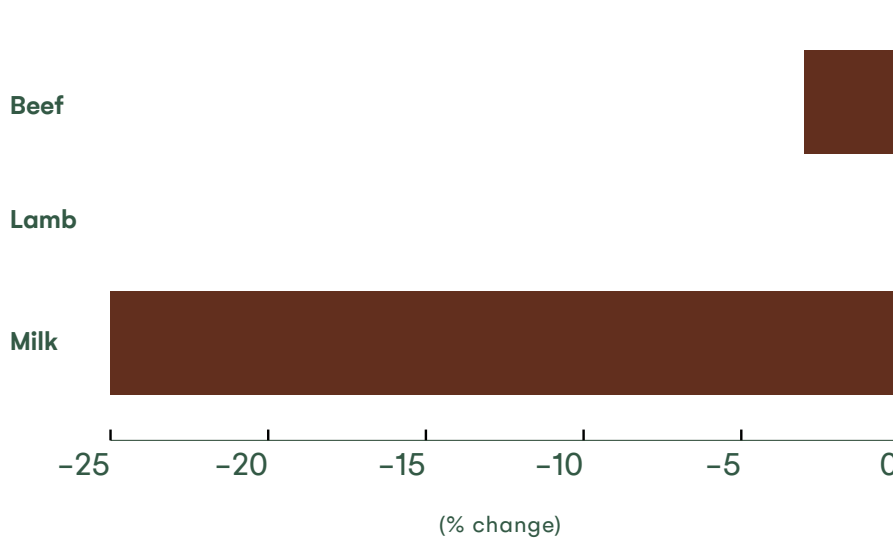
agroforestry. However, approximately a third of total production would come from urban areas, based on the assumption set out in Chapter 3 that around half of the UK's available urban allotment area, 20% of cultivated garden space and all current urban fruit trees would be used and harvested for fruit and vegetables.

A wide range of vegetables is assumed in the model, with the bulk of production being brassicas (e.g., cabbages, kale and broccoli), root vegetables (e.g., carrots, parsnips and beetroot), alliums (e.g., onions, leeks and garlic), squashes and salads. Tomatoes, peppers and other vegetables grown in polytunnels and greenhouses would also be produced, extending the season for producers and consumers.

Fruit production would comprise roughly 80% top fruit and 20% soft fruits (such as strawberries, raspberries and black and red currants).

Potato production, however, would fall by around 20%. This is mainly due to a reduction in yields, resulting from the removal of nitrogen fertiliser and fungicides.

FIGURE 4.6: CHANGES IN PRODUCTION (MILK, BEEF AND LAMB)

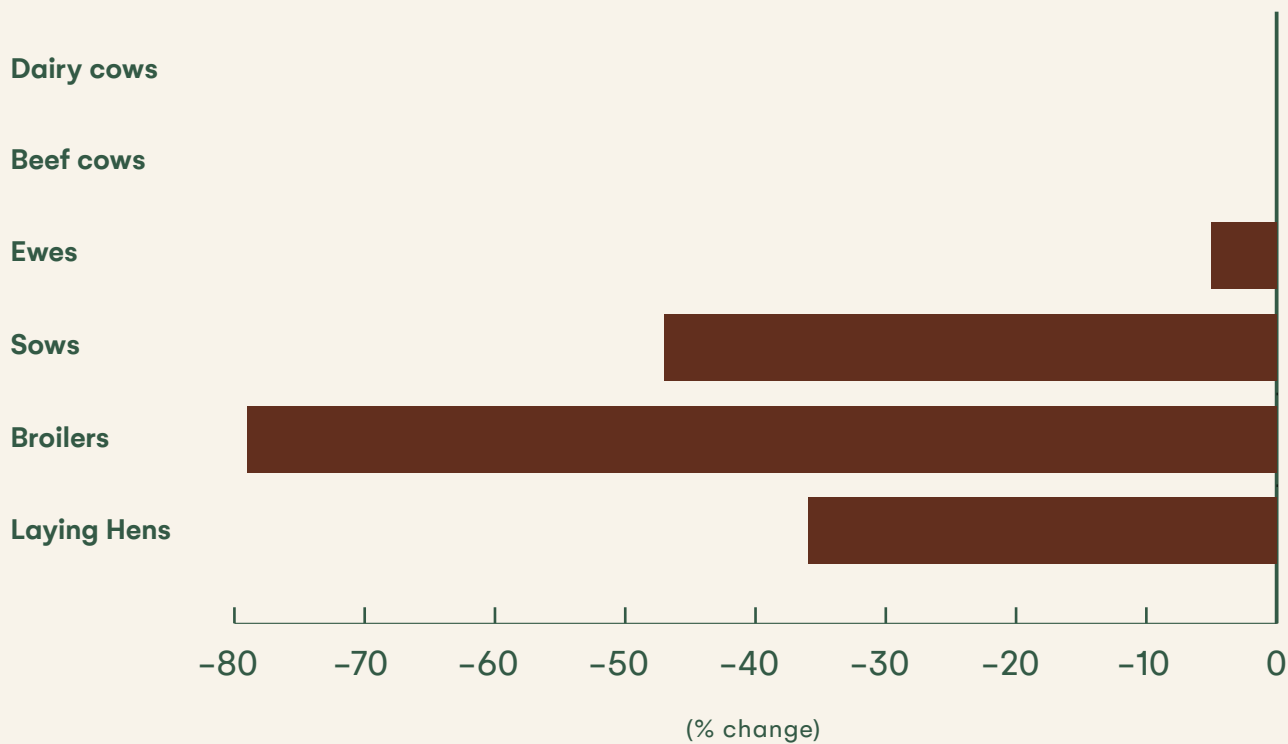


Production of beef and lamb would remain close to current levels, and dairy production would decline by around a quarter. Dairy production would fall due to lower milk yields, brought about by a reduction in the amount of cereals used for feed as part of the shift to high-welfare, grass-based systems of production.

As explained throughout this report, grazing livestock are integral to the sustainable farming systems we have modelled, due to their role in helping to build soil fertility (reducing the need for chemical inputs); improving biodiversity; recycling nutrients; and making use of land that can't be used to grow crops for humans.

For these reasons, the model has prioritised the production of beef, lamb and milk over the production of chicken, eggs and pork. This decision is clearly shown in figure 4.7, which reveals how livestock numbers would change, with major reductions in the numbers of pigs and chickens, but no reductions in dairy and beef cattle numbers, and a relatively minor reduction in sheep numbers. Importantly, however, **there would be a major redistribution of grazing livestock across the UK.** On the one hand, numbers would increase in parts of the arable south and east due to their integration into mixed farming systems, whilst on the other hand, there would be a reduction in grazing livestock numbers in some grassland-dominated areas of the north and west, due to the de-intensification of production systems.

FIGURE 4.7: CHANGES IN LIVESTOCK NUMBERS*



*Current numbers taken from Defra (2019)



Thistleyhaugh Farm and Healy Farm Northumberland

Duncan and Angus Nelless are organic livestock farmers, producing 100% pasture-fed beef and lamb, as well as free-range pork and turkey. 15 years ago, they decided that they needed to change the way the farm was operated to improve its profitability, and so they converted to organic and placed an even greater focus on grazing management.

This move to a low input, low cost, productive system has paid dividends for the farm's financial viability, enabling them to make a profit without relying on basic payments from government. It has delivered major benefits for the environment too, with visible increases in biodiversity and a reduction in the farm's carbon footprint, showing that productivity, profitability and environmental sustainability can go hand in hand.

Size: 560 hectares

- 200 hectares permanent pasture
- 170 hectares temporary grassland
- 100 hectares rough grazing
- 90 hectares of woodland, watercourse and other non-agricultural land

Food output

- **Beef:** 37 tonnes
- **Lamb:** 23 tonnes
- **Pork:** 117 tonnes
- **Poultry:** 6.8 tonnes

Number of employees

- Four full time and two part time







CHAPTER FIVE

Implications for diets and self-sufficiency

Chapter 5 — Sustainable diets

Summary

This report was inspired by a question that millions of people are now asking – ‘what should I eat to be healthy and sustainable?’ Our response is that we should align our diets to what the UK can sustainably produce, because without changing what we eat, it will be impossible for farmers to switch to sustainable production methods and remain economically viable.

The findings of this report show that if this transition were enacted, there would still be sufficient supplies of each of our key, staple foods to maintain current levels of UK self-sufficiency, provided we ate differently, ate less (in line with dietary guidelines), and wasted less food.

Following a transition to sustainable and regenerative agriculture, the **per person availability of UK-grown foods** would change in the following ways:

- **Vegetables and fruit:** Twice the amount of seasonal vegetables and fruit would be available for consumption.
- **Beef and lamb:** Due to the importance of grazing livestock in sustainable farming systems, around the same amount of beef and lamb would be available.
- **Dairy:** There would be around a third less dairy available for consumption, with products coming from high-welfare, pasture-based systems.
- **Pork and chicken:** The availability of pork and chicken would reduce dramatically, as a result of the end of intensive, grain-fed systems and a move to higher welfare, free-range methods of production.
- **Eggs:** For the same reasons as pork and chicken, there would also be fewer eggs available.
- **Grains and pulses:** Due to the major reduction in the amount of grain fed to livestock, about the same amount of cereals would be available for human consumption. The amount of pulses (i.e. peas and beans) would increase substantially, due to their importance as part of sustainable farming systems.

Our results also show that **sustainable farming systems in the UK could meet many of our nutritional needs, including:**

- **156% of protein requirements:** from high-welfare, mainly pasture-based livestock products as well as from pulses and cereals.
- **67% of fats:** mainly from livestock products, vegetable oils and cereals for human consumption.
- **104% of carbohydrates:** the majority from cereals, but with important contributions from potatoes, pulses, vegetables, fruit and dairy products.

Food security and trade: While the UK would produce less food than it does today, our results indicate that through a shift to healthier diets, reductions in food waste and the elimination of imported protein feeds for livestock, the UK would be able to maintain, and likely improve on, its current levels of self-sufficiency, which would bring benefits for food security and the environment. International food trade would, of course, remain important in the future, but this should be restricted to products grown to high environmental standards, in order to prevent UK farmers from being undermined by cheaper imports, often produced to lower standards.



In Chapters 1 to 4, we modelled how land use and food production might change in a sustainably farmed UK, using the following three steps:

- 1. Divide the UK's farmland area according to variations in agricultural capability**
- 2. Design a set of farming 'systems', appropriate to the productive capacity of a particular category of land**
- 3. Calculate the amount of food that this nation-wide approach to sustainable farming would produce**

This chapter looks at the fourth and final step of our methodology — **calculating what impact these changes might have on the diets of individual citizens, and by extension, what a shift to more sustainable patterns of production and consumption might mean for the UK's need to import food.**

Before presenting our findings and recommendations, it should be made clear that we are not trying to impose any particular diet on individual citizens. Instead, the aim of this report is to explore what the outputs and impacts would be following a transition to sustainable farming across the UK. However, although we support every citizen's right to choose what they eat, a change in diets will be necessary to support the transition to sustainable farming systems, which is needed to avoid irreversible climate change and soil degradation, restore nature and rebuild a resilient food system that promotes health.

As is also explained in previous chapters, the research underpinning this report has necessitated a number of assumptions relating to land use and specific

enterprises, about which we have been completely transparent. As an example, the grasslands which would comprise three-quarters of UK farmland could be used to produce beef, lamb, dairy products or free-range pork and poultry in different proportions, and in each case, we had to make a decision about the allocation of land and feed to these livestock enterprises. It was necessary to make similar decisions in relation to the enterprise allocation on arable land. In making these choices, we have also been mindful about the need to promote public health, hence the decision to increase the area devoted to fruit and vegetable production.

The figures in table 5.1 highlight the kind of changes we would need to make if we were to align our diets more closely to what the UK can sustainably produce.

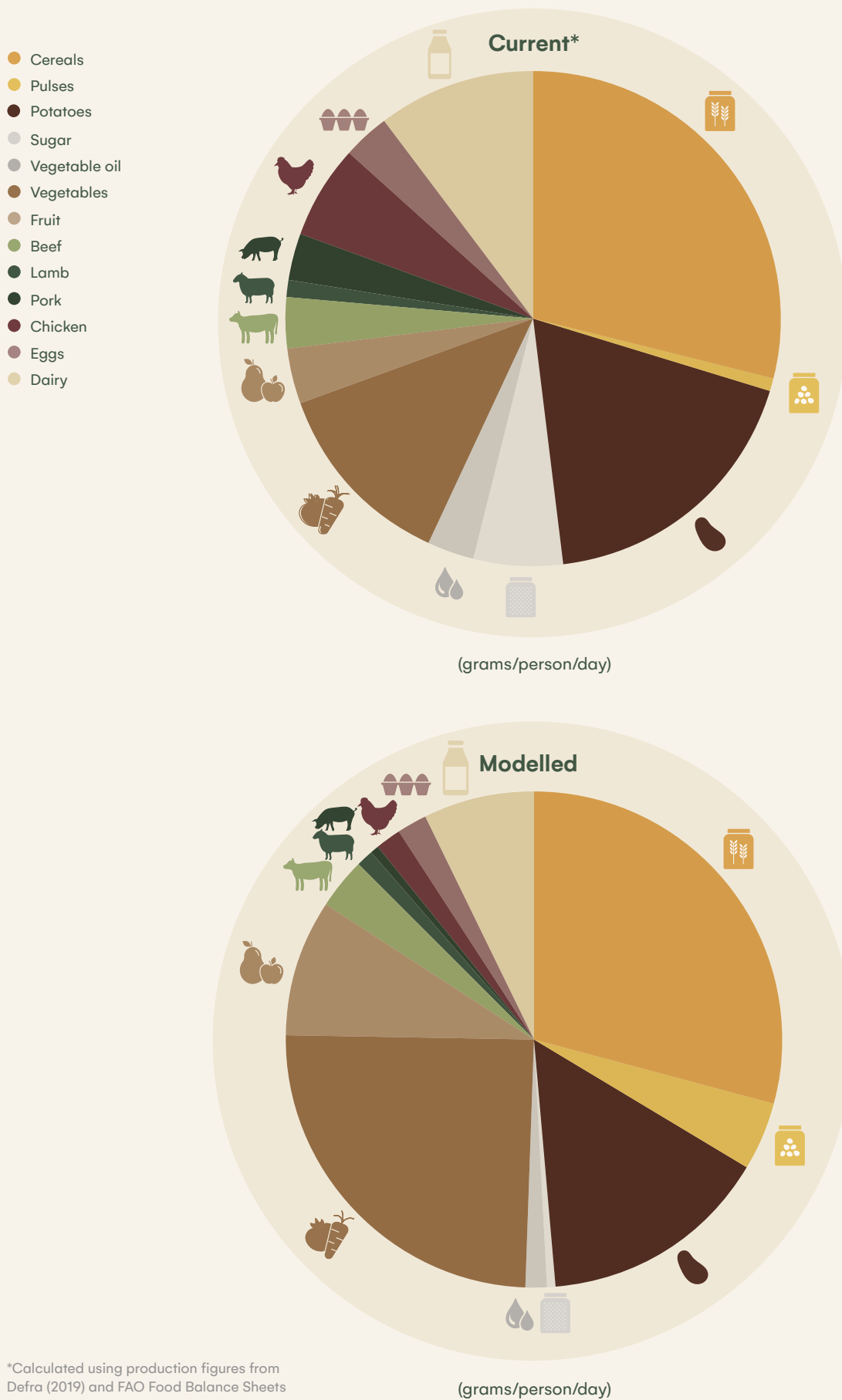
These figures do not show what we currently consume in the UK, nor should they be read as a prescriptive diet for the future, as they don't include any imports or exports. Instead, the figures show how much UK-produced food is available per person currently, and how much would be available per person under sustainable farming conditions 10 years in the future (when the UK's population is projected to have risen to 70 million people). **They are, therefore, an illustration of how the consumption of UK-grown foods might change were we to align our diets to what the nation can produce sustainably.** These figures have been adjusted to take into account food processing (for instance, milling to produce flour) and for dairy, the figures refer only to the solid fraction of milk (i.e., with the weight of the liquid removed). They also take no account of fish or alcohol, as these, while significant, fell outside the scope of this report.

**TABLE 5.1: VOLUME OF FOOD THAT UK FARMS CONTRIBUTE PER HEAD OF POPULATION
— CURRENT VERSUS MODELLED**

	CURRENT* (grams/person/day)	MODELLED (grams/person/day)	% CHANGE
Cereals	238	232	-3%
Pulses	7	35	+411%
Potatoes	149	118	-21%
Sugar	48	6	-88%
Vegetable oil	24	11	-53%
Vegetables	103	194	+88%
Fruit	29	71	+142%
Beef	28	26	-7%
Lamb	9	8	-4%
Pork	24	6	-77%
Chicken	50	13	-74%
Eggs	27	14	-48%
Dairy	82	57	-30%

*Calculated using production figures from Defra (2019) and FAO Food Balance Sheets

FIGURE 5.1: PER PERSON AVAILABILITY OF FOOD FROM UK PRODUCTION
— CURRENT VERSUS MODELLED



Aligning our diets to sustainable production: the key ingredients

Overall, the nationwide transition to sustainable farming would lead to an increased availability of seasonal vegetables, fruit and pulses; slightly less beef and lamb and about 30% less dairy, produced from high-welfare, mainly pasture-based systems; significantly less chicken, eggs and pork — with the remaining production coming from free-range systems with high standards of welfare; and roughly the same amount of grain-based foods, but from a greater variety of cereals including more oats and rye.

FRUIT AND VEGETABLES

Under our model, **the supply of UK-produced vegetables would double, equating to around two and a half portions of veg per person per day.** This would mainly consist of a diversity of vegetables grown in fields and in urban areas, including a wide variety of brassicas (e.g., cabbages, broccoli, cauliflower), root vegetables (e.g., carrots, parsnips, beetroot), alliums (e.g., onions, leeks, garlic), squashes and salads. However, thanks to a significant increase in the area under unheated glasshouses and polytunnels, vegetables grown indoors would also play an important role in feeding the nation, greatly extending the seasonal window for many producers growing vegetables.

It's a similar story with fruit, resulting from a substantial expansion of the area devoted to fruit production and agroforestry. This major increase in supply would equate to a little under one portion of UK-grown fruit per person per day. Four-fifths of this would comprise orchard fruits (principally apples and pears, as well as plums and cherries),

with the remaining 20% consisting of soft fruits (such as strawberries, raspberries and black and red currants).

Overall, this would lead to a UK-grown contribution of just under three and a half portions of fruit and veg per day — not much less than the total amount, which includes imports, consumed by the average adult today. Should there be a demand for it (and, of course, the necessary increases in labour to make it viable) it would be possible to increase UK fruit and vegetable production even further, including in urban areas, as recent studies have shown.¹

BEEF AND LAMB

As part of the transition to sustainable food systems, we will need to move away from the consumption of intensively reared, grain-fed meat, milk and eggs. Instead, 100% grass-fed and mainly grass-fed beef, lamb and dairy, would form an important part of our diets, becoming the new staple livestock products.

Such grass-fed products will not only be available from areas currently dominated by pasture, but increasingly from arable farms too, where significant areas of grassland will be introduced, as part of their sustainable rotations. These can only be turned into food through the use of grazing animals.

For the reasons described above, the amount of UK-produced beef and lamb available for consumption would fall very slightly to 26 grams and 8 grams per day respectively, equivalent to about one portion of steak or mince a week, and around two portions of lamb mince per month.

Some might question the health implications of a relatively minor reduction in the availability of beef and lamb, given concerns around the link between red meat and poor health. This is an issue touched on in the section on ‘Sustainable and Healthy Diets’ later on in this chapter. However, it’s worth noting here that the amount of red meat available per person in our model would be below the maximum recommended daily intake of 70 grams per person per day.² It also needs to be remembered that these figures only refer to the amount available per person from UK production, and so don’t account for any imports or exports.

DAIRY

As a result of the move to high-welfare, pasture-based dairy systems, average yields would decline and so the overall availability and consumption of UK-produced dairy products would fall by close to a third.

As part of the transition to sustainable farming systems, **large-scale dairying with permanently housed cows would be phased out in favour of an increased number of much smaller dairy herds**, often using native breeds, many of which will be re-integrated into mixed farming systems. **These herds would be reared in pasture-based systems, with no use of soya meal and a smaller amount of cereals being fed**, compared to today. As a result of these changes, milk yields would be lower but dairy cows would benefit from improved animal welfare, and the nutritional quality of dairy products would improve — due to the higher percentage of grass and forage in dairy cow diets.³

The amount of dairy available would equate to eating no more than about 54g of hard cheese a day or drinking a little under two glasses of milk a day.

POULTRY AND PORK

Changes in poultry and pork consumption would constitute the most dramatic dietary change resulting from the transition to sustainable farming. Because grain production would halve, there would no longer be enough grain to maintain our current levels of chicken and pork production, as grain would be prioritised for human consumption rather than animal feed.

Much like the de-intensification of the dairy industry, **poultry and pork production would be restructured in our model, with a move away from permanently housed flocks and herds, fed huge quantities of grain and imported protein feeds, to free-range, high-welfare systems.** Pigs and poultry would be integrated into mixed farming operations, consuming a significant quantity of forage and waste products, including safely-treated food waste, alongside a smaller quantity of cereals.

Consequently, the amount of UK-produced chicken available in our diets would reduce by roughly 75%, from 50 grams per person per day, to 13 grams. This would equate to eating, on average, no more than one breast fillet of chicken every other week.

The amount of UK-produced pork available per person would fall by a similar amount, from 24 grams to 6 grams per person per day, which would equate to eating no more than about two to three rashers of streaky bacon per week.

In keeping with the reductions in chicken, **the number of UK produced eggs available per person would also reduce** from about 3–4 eggs a week to 2 eggs a week.

Critics might argue that such a dramatic reduction in poultry and pork products is unrealistic, given current dietary patterns and massive demand for these products.



We accept that other modellers might wish to include higher proportions of these products in future diets, but as the recent conflict in Ukraine is indicating, we may be reaching the end of the chapter on mass-produced, intensively reared, cheap white meat, due to the dramatically increasing cost of feed and fertiliser inputs. As a result of the transition to sustainable farming practices, pork and poultry products would almost certainly become much more expensive. It is also worth remembering that our current levels of consumption are a relatively recent phenomenon. Pre-1960s diets included far less grain-fed livestock products, with chicken consumption restricted to special occasions ('high days and holidays').⁴

CEREALS

We have assumed a major reduction in the amount of cereals fed to livestock, and this means that per person, the

amount of UK-grown cereals available for human consumption would be almost the same as at present. There would be changes to the proportion of different grains in our diet, with fewer wheat and barley products and considerably more oats and rye. This is because we have assumed a greater diversity of crops.

Since the Second World War, grain production has increased dramatically, due to the emergence and widespread availability of nitrogen fertilisers and pesticides. This has had profound consequences for UK agriculture, including the intensification of livestock production, caused by the increased availability of grain for animal feed. This in turn, has had major impacts on British diets, with a fundamental shift in the intake of animal-sourced foods and many people now expecting plenty of cheap chicken, pork and dairy products.

However, this system has been built on a false premise — the assumption that it is cheap to produce grain in this manner. The true cost of modern-day grain production is, in fact, extremely expensive, once you take into account its impact on the environment, human health and the longer-term productive capacity of farmland soils. For these reasons, we have modelled a different approach to cereal production in this report, with grains being grown as part of diverse crop rotations. As a result of this transition, as well as the elimination of synthetic fertilisers and pesticides, there would be a 50% reduction in total output.

PULSES

Because pulses play such an important role in crop rotations (fixing nitrogen and breaking pest-cycles) and contain significant levels of protein, **the production**

of pulses such as peas and beans would increase significantly, and so would form a greater percentage of our dietary intake — up from 7 grams of home-grown pulses available per person per day at present, to 35 grams per person per day.

Our model only includes peas and beans, but it is possible that in the future a sustainable diet could include a wider variety of pulses, such as UK-grown chickpeas and lentils, which are currently being trialled by some farmers.⁵

There is also the potential to increase the amount of pulses in our diets by processing them into flours which can then be used in a wide variety of products.⁶ As an alternative source of protein, these products could make it easier to adapt to eating less meat.



SUGAR

There is widespread agreement that we need to reduce the amount of sugar we consume in the UK, with intake well in excess of current recommendations.⁷

There is, however, currently a more contentious debate about how and where our sugar should be grown. Historically, most of the sugar in our diets was imported as cane sugar from overseas, but during the inter-war period, the subsidisation of sugar beet meant that farmers in the UK were able to produce a significant portion of UK sugar supply. Today, over 60% of the nation's demand is met by UK producers.⁸

The post-Brexit elimination of tariffs on imported cane sugar has sparked concerns that this will undercut British producers and lead to greater imports of cane sugar.⁹ However, **the production of sugar in the UK is also associated with major health and environmental problems, including soil erosion and the use of the otherwise banned neonicotinoid insecticides.**¹⁰ While there are contentious issues here, it is clear that reducing both UK production and consumption of sugar would benefit our health and the environment.

As a result, we have modelled a significant reduction in the amount of UK-grown sugar available per person. It should be remembered, however, that UK production of fruit would double. Fruit is a natural source of sugar which avoids the negative health impacts of refined sugar because it is consumed with fibre, which slows down the absorption of sugar into the bloodstream.

VEGETABLE OILS AND FATS

Like sugar beet, the availability of UK-produced vegetable oils will also decline significantly under our modelling. This is largely due to the difficulties currently

experienced in producing oilseed rape (by far the most significant oilseed crop grown in the UK), without the use of pesticides. Even if we assume that we would no longer use rapeseed oil for non-food uses (according to FAO data, around 30% of the UK's supply of rapeseed oil is used for these purposes), this would still mean a big drop in the amount of home-grown vegetable oil available for human consumption.¹¹

This major decline in the availability of rapeseed oil would be partly offset by a significant increase in the availability of linseed (otherwise known as flaxseed) oil, as it is a crop that grows well in the types of sustainable farming systems modelled in this report.

It is also important to note that there are promising trials showing that rapeseed oil can be produced in the UK without the use of pesticides, and so it may be that the UK would be able to supply significantly more vegetable oil in a regeneratively farmed future than we've assumed here.¹²

Finally, it's worth noting that animal fats would become proportionately more important in our model. While the total amount of animal fat available for consumption would fall slightly (as a result of the reduction in total livestock numbers), our assumptions around the use of more native breeds reared in pasture-based systems would mean that milk would have a higher fat content and livestock carcasses would have a greater cover of fat too. We have also assumed that all of the recoverable fat trimmed off carcasses during the butchering process would enter the human food chain (unlike the present day, where half is used for other purposes or wasted),¹³ which would increase the availability of animal fats for cooking and processing purposes.

Sustainable and healthy diets

Enabling a shift to the kinds of sustainable farming systems modelled in this study will require us to make some significant changes to what we eat, but dietary change will also be necessary if we are to address the epidemic of diet-related disease. At present, 63% of the UK's adult population are overweight or obese, and diseases related to obesity are estimated to cost society £27 billion a year — a figure that is predicted to almost double by 2050.¹⁴ However, while there is unanimous agreement around the need for a shift towards healthier diets, there is a more heated debate around what these changes should be.

Some actions are widely agreed upon — for instance, the need to consume fewer calories, less sugar and refined carbohydrates generally, as well as more fruit, vegetables and pulses. Incidentally, our results show these are all changes that a shift to sustainable farming systems would help promote.

Other foods, however, have been the subject of more discussion, with the question of how much animal-sourced food we should eat being especially contentious — particularly when it comes to red meat and saturated fats. Various studies have linked these to a higher risk of disease and death,¹⁵ while only a few studies have found no link.¹⁶ As a result, there have been a growing number of calls to dramatically reduce, or even eliminate, our consumption (and therefore production) of beef and lamb. This has also contributed to the shift away from a predominance of animal fats to vegetable oils in our diets over the past century.¹⁷

There have, however, been questions raised about the strength of evidence used to support the link between red meat and poor health.¹⁸ Beef and lamb are also nutrient-dense foods which can be produced from grass and other human-inedible feeds. They therefore provide a supply of key nutrients and calories that is additional and complementary to that which we obtain from crops. At a time of growing pressure on arable land, there is a risk that significantly reducing or eliminating our consumption and production of these foods might have negative impacts on food security, particularly in relation to protein, fat and micronutrient supply — a serious and growing concern following the disruptions to global food trade precipitated by the war in Ukraine, along with extreme weather in many food producing regions of the world.

It's also important to note that the amount of red meat available per person in our model would be below the maximum recommended daily intake of 70 grams per day, and so is in line with government health advice.¹⁹ Finally, it's worth reiterating here that the per person figures discussed in this chapter are the amounts available for consumption from UK production, and don't include imports.

Whilst there are many other important aspects to the discussion around diets and health including the supply and availability of micronutrients (which are essential for human health), examining these in detail was not within the scope of this report. We therefore acknowledge that the debate around what constitutes the most nutritious and balanced diet will continue. Instead, **our modelling is based on the**

premise that sustainable diets should be shaped from the ground up, i.e., according to what UK farmers can sustainably produce. This ‘bottom-up’ approach differs from some previous reports, such as the recommendations made in the EAT–Lancet report, which were based on an assessment of the health impacts and environmental footprints of different foods.²⁰

That said, many readers of this report will now be wondering what aligning our diets

to the sustainable productive capacity of the UK will mean for our individual daily nutrition. In an attempt to answer this question, we first looked at the contribution that sustainable UK production could make to our intake of calories and macronutrients, and compared this to the potential contribution from UK production at present, as shown in Table 5.2. These figures were calculated using the values in Table 5.1 and data on the calorie and macronutrient contents of different foods.²¹

TABLE 5.2: CONTRIBUTION OF HOME-GROWN STAPLE FOODS TO NUTRITION PER PERSON — CURRENT VERSUS MODELLED

	PROTEIN (g/day)		FAT (g/day)		CARBS (g/day)		CALORIES (kcal/day)	
	Current	Modelled	Current	Modelled	Current	Modelled	Current	Modelled
Cereals	35	33	7	9	236	224	1092	1054
Pulses	0	8	3	1	19	15	23	95
Vegetable oil	0	0	24	11	0	0	218	103
Sugar	0	0	0	0	50	6	189	22
Potatoes	3	2	0	0	24	19	101	80
Fruit & Veg	4	7	1	1	10	23	58	128
Meat & animal fat	23	10	13	18	0	0	210	193
Eggs	3	2	2	1	0	0	35	18
Dairy	21	16	23	18	29	20	396	307
Total	89	78	73	60	368	307	2323	1999

Future food security

While table 5.2 shows that sustainable farming can make a significant contribution to the nation's supply of calories and key nutrients, the amount of food available per person from UK production would decline due to the fall in yields.

Clearly, importing more food would render the move to a more sustainable way of farming at home futile. In addition to exporting our environmental impact abroad, UK farmers would be at risk of being undercut by cheaper foods often produced to lower standards, ultimately undermining their ability to farm sustainably.

However, we also know that what we currently eat as a nation is not only well beyond our share of planetary resources but is also bad for our health: we consume too many calories, too much sugar, too many highly-processed foods, and not enough fruit, vegetables, wholegrains and pulses. The impact on our health, life outcomes and care costs is huge.

This then raises the question of what would happen to the UK's self-sufficiency if we ate more healthily as a nation? Would we be able to avoid the massive increase in imports that a more sustainable approach to food production would otherwise entail?

As tables 5.3 and 5.4 show, the answer is yes — if we ate according to the recommended levels of intake for calories and macronutrients, the UK would be able maintain its current levels of self-sufficiency when it comes to the supply of calories, protein, fat and carbohydrates, and perhaps even improve on them. Table 5.3 shows what the UK's current per person demand for food, including imports, looks like (prior to any waste), as well as the percentage of this demand that is currently met by UK production (demand figures are from the FAO).²² In table 5.4, we can see how the current situation compares with the levels of self-sufficiency that a sustainably farmed UK could achieve, were its citizens to consume the amount of calories, protein, fat and carbohydrates recommended by the European Food Safety Authority (2,300 kcal on average).²³



TABLE 5.3: CONTRIBUTION OF CURRENT UK FARMING TO THE DEMAND FOR CALORIES AND MAJOR NUTRIENTS (I.E., ASSUMING CURRENT DIETS)

	SUPPLY FROM CURRENT UK FARMING* (per person)	CURRENT DEMAND** (per person)	% OF CURRENT DEMAND MET BY CURRENT UK FARMING
Calories	2323	3380	69%
Protein	89	105	85%
Fat	73	139	53%
Carbohydrates	353	428	83%

* Production figures from Defra (2019) ** From FAO Food Balance Sheets

TABLE 5.4: CONTRIBUTION OF SUSTAINABLE UK FARMING TO THE DEMAND FOR CALORIES AND MAJOR NUTRIENTS (I.E., ASSUMING RECOMMENDED INTAKE)

	SUPPLY FROM SUSTAINABLE UK FARMING (per person)	RECOMMENDED INTAKE* (per person)	% OF AVERAGE RDI MET BY SUSTAINABLE UK FARMING
Calories	1999	2300	87%
Protein	78	50	156%
Fat	60	90	67%
Carbohydrates	307	294	104%

* Figures taken from EFSA, with fat and carbohydrate totals being the average of a recommended range.

These figures should be interpreted as approximate values, indicating in broad terms how self-sufficiency would change between the present day and in a sustainably farmed future, assuming a change in diets. **However, what is clear is that when it comes to the overall supply**

of calories and major nutrients, the UK would be able to maintain its current levels of self-sufficiency in these, and may even be able to reduce imports, particularly of protein — providing, of course, our diets were to change so that they were in line with recommended intakes.

By doing so, sustainable farming systems in the UK could meet many of our nutritional needs:

- **156% of protein requirements:** from livestock products produced in high-welfare, pasture-based systems, as well as from pulses (peas and beans) and cereals.
- **67% of fats:** mainly from livestock products, vegetable oils and cereals for human consumption. Although we would produce less fat than today, our modelling also assumes a reduction in fat intake, in line with health recommendations.
- **104% of carbohydrates:** the majority from cereals, but with important contributions from potatoes, pulses, vegetables, fruit and dairy products.
- **Micronutrients:** estimating the changes in the availability of key micronutrients, including essential amino acids, vitamins, minerals and antioxidants is beyond the scope of this report. There is, however, significant evidence to suggest that the transition towards grass-fed meat and dairy, plus the increasing UK production of fruit and vegetables, would increase the density of micronutrients in foods produced from sustainable farming systems in the UK.²⁴

Another important issue relating to self-sufficiency that is not captured in these figures, is the import of animal feed. At present, the UK imports a variety of ingredients for livestock feed, but the most significant in terms of environmental impact is soya bean meal. The UK currently imports approximately 3 million tonnes of soya in total, grown on an overseas area almost the size of Wales, and at least 75% of this is used for livestock feed, either as imported soya meal itself, or ‘embedded’ in imported livestock products fed with soya, principally chicken and pork.²⁵ This comes at a huge environmental cost and represents a major part of our overseas footprint, yet the import of these ‘shadow acres’ is often overlooked in discussions around the sustainability of food production. **For these reasons, we assumed no use of imported livestock feeds (including soya bean meal).** This would deliver major benefits for the environment and would also help to reduce the UK’s reliance on animal feeds produced in areas at extreme risk of deforestation and soil erosion.



Key issues and discussion points

FOOD WASTE

In the UK, over 7% of all harvested food is wasted before it even leaves the farm.²⁶ Farms therefore have a key role to play in reducing, reusing and recycling food waste by applying the principles of the circular economy, including through the greater use of food waste as a source of animal feed. However, most food waste in the UK occurs beyond the farmgate, with 22% of all food being wasted, much of this occurring in homes.²⁷ This has major negative impacts upon the environment, and for this reason, **we have assumed a 50% reduction in food waste in this study, in line with the**

UN's Sustainable Development Goals and the targets set out in the Courtauld Commitment.²⁸

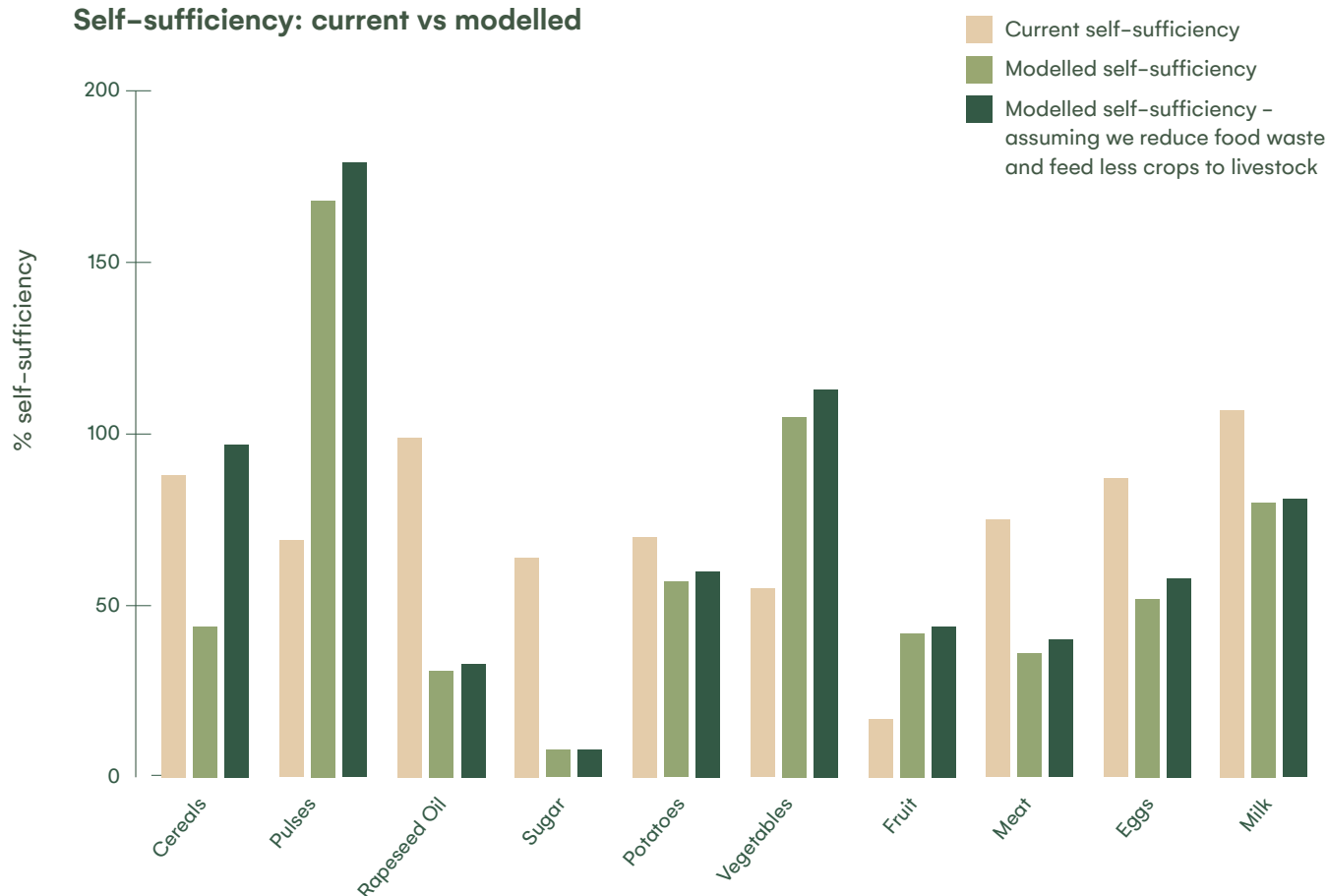
Another wasteful aspect of our current food system is the feeding of huge quantities of human-edible feeds, in particular cereals, to livestock. As explained in earlier chapters, this is a highly inefficient practice from a nutrient supply perspective, as it leads to a net loss of calories and most major nutrients from the food system. This, along with the significant drop in cereal production modelled in this study, is the main reason why we assumed a major reduction in the amount of cereals fed to livestock.

Figure 5.2 shows what impact reducing food waste and the use of human edible feeds for livestock would have on the UK's ability to feed itself. It compares current levels of self-sufficiency (beige columns) with modelled levels of self-sufficiency assuming no reductions in the use of crops for livestock feed and no reductions

in food waste (the light green columns), and modelled levels of self-sufficiency assuming a major reduction in the amount of cereals used as livestock feed and a 50% reduction in food waste (the dark green columns). It's important to note that these figures assume no change in diet.

FIGURE 5.2: THE IMPACT ON SELF-SUFFICIENCY OF SUSTAINABLE FARMING PRACTICES, REDUCING FOOD WASTE AND FEEDING LESS TO LIVESTOCK

Self-sufficiency: current vs modelled



We can clearly see that by reducing food waste and the amount of cereals given to livestock, we would be able to maintain or increase our current levels of self-sufficiency in human-edible cereals, pulses, fruit and vegetables. The difference in cereals is particularly notable, and this is because so much of the UK's cereal crop is currently fed to livestock. What is also clear, however, is that **without a change in**

diets, we would need to import much more rapeseed oil, sugar, meat and eggs, and this is why dietary change is so important — as discussed earlier in the chapter.

INTERNATIONAL TRADE

Through a shift to healthier diets, a reduction in food waste and the elimination of imported protein feeds for livestock,

our results indicate that the UK would be able to maintain, and likely improve on, its current levels of self-sufficiency, which would bring benefits for food security and the environment. However, for various reasons, we would need, and indeed want, to continue trading certain foods with other countries in the future.

The UK has a relatively high population density in relation to its farmland area. In addition, a high proportion of farmland has relatively limited productivity because it is only suitable for growing grass. By way of comparison, France has a similar sized population to that of the UK, but it has over one and a half times as much farmland and three times as much arable land.²⁹ As such, it is unsurprising that some food imports to the UK would still be necessary to meet the requirements of a healthy diet.

For instance, the figures in table 5.2 suggest that we would need to continue importing sources of fat. If, however, we were to eat according to the recommended levels of intake set out in table 5.5, these could be imported at a slightly lower level than today. As is discussed elsewhere in the report, the need to import fats could be reduced further still, by assuming a larger area of oilseeds and a greater fat cover on animals than we modelled. Despite a major increase in production, we would also need to continue importing fruit and vegetables (though again, to a lesser extent than currently) if we wanted to follow the recommended five or more portions per day.

There are also other foods like tea, coffee, chocolate, bananas and rice, which cannot be grown in the UK's climate and which we would therefore want to continue importing. There are, of course, important issues around the sustainability of producing and importing these foods, and these should be factored into the decisions made by government, companies and consumers alike.

In addition, there are some key commodities where we have long-standing reciprocal trading arrangements. One example is that, while we export approximately a third of our lamb to Europe, we also import a similar amount from New Zealand.³⁰ This is due to the demand for prime lamb in the spring, at a time of year when most lambs are only just being born in the UK. This could be changed over time if consumers could be encouraged to eat more mutton and hogget in the spring. A further example is that, while we import large quantities of hard milling wheat from France and some other countries, because it is needed to make the type of loaves currently favoured here, we export a similar quantity of soft milling wheat (especially to France) which is more suitable for making the baguettes favoured by the French.³¹

In relation to other exports, and with food security in mind, if the farmers of any nation can produce a genuine surplus of a food commodity which is in deficit in other countries, or if it is possible to add value to primary commodities such as milk and grain, and there is a demand for such products overseas, it would be inappropriate not to support such trading activity.

However, it is crucial that where international trading does occur, this should take into account the sustainability of production, whereby robust standards are applied to all imports, with any which fall below these being subject to tariffs.

Drawing from the above, our modelling is based on the assumption that it is preferable for any nation to produce as many of its staple food requirements as is compatible with sustainability objectives, and to move to an international trading platform only if the conditions outlined above are met.

Linking the measuring of on-farm sustainability to food labelling

A key challenge identified in this report is the ability of individuals to identify and purchase sustainable produce. Many consumers wanting to make sustainable choices are confused and struggle to differentiate products due to the limited information available. To support a transition to sustainable farming and diets, consumers, corporates — as well as businesses and governments — need to be able to identify sustainably produced food. But until now, there has been no consistent, holistic way of measuring the impacts of a farming system.

The SFT believes this lack of a common framework for measuring on farm sustainability, and the subsequent information gap, is a critical barrier slowing the transition towards sustainable food and farming systems. It makes it hard for farmers to know the impact of their practices across the whole farm, benchmark their performance with other farmers or to be rewarded for best practice. It also allows the environmental costs of food production to remain hidden and unsustainable practices to go unchallenged.

A growing coalition of farmers, farm advisors, scientists, retailers, financial institutions, government actors and NGOs is now forming behind the need for a common framework for defining and measuring sustainability at farm level. The SFT have been leading on this, with the development of a single set of categories and subcategories, currently framed as a Global Farm Metric (GFM), to define the social, economic and environmental impacts of all farming systems.

When adopted, the framework would be embedded into existing farm audits, assessments and certification schemes, so that all are aligned and have a common starting point for farm level data collection.

As well as aiding the understanding of whole-farm impacts and reducing the duplication of data collection for farmers, the GFM will create a baseline of data that could be used to benchmark performance and monitor progress towards local, national and international sustainability goals. This will create a consistent and verifiable thread of data to inform on-product labelling, providing an accessible way to compare products and make more informed decisions.

In addition to empowering individuals to make more sustainable food choices, a common framework for measuring on-farm impacts will help to create a supportive economic and policy environment that rewards the delivery of public goods and financially incentivises more sustainable farming. Rolled out globally, it can be used to set international standards for agriculture and monitor progress towards Sustainable Development Goals. It can also inform global trade agreements, so that farmers are not undercut by food imports produced to lower standards.

Ultimately, providing individuals, communities and organisations with the information to choose genuinely sustainable food will help shift the balance of financial advantage towards more sustainable food and farming systems.

FIGURE 5.3: GLOBAL FARM METRIC — THE 11 MEASUREMENT CRITERIA



Case study

Hill Top Farm North Yorkshire

Situated at 800 to 1800ft above sea level, Hill Top Farm is a 100% organic and pasture-fed hill beef and sheep farm situated in the limestone uplands of Malham, in the Yorkshire Dales National Park.

Until the early 2000s, the farm was run in a fairly conventional fashion, with 800 crossbred sheep reliant on bought-in concentrate feed, and no cattle. Since then, however, Neil Heseltine and Leigh Weston have set about improving the environmental and financial sustainability of the farm, by dramatically reducing the number of sheep, introducing a 150-strong herd of Belted Galloway cattle and adopting conservation grazing practices designed to support biodiversity. This has allowed the farm to completely eliminate the use of bought-in feeds, and has not only made the farm more profitable and biodiverse, but has also improved the quality of life for Neil, Leigh and their stock. Carbon audits have also shown that these changes have enabled the farm to move from being a net source of carbon, to a net sink.

Size: 490 hectares

- 80% above the moorland line
- Much of the remaining 20% under traditional hay meadows, with some cut for winter feed

Food output

- **Beef:** 10 tonnes, plus 20 breeding females sold off the farm each year
- **Lamb:** 1.5 tonnes, plus 50 breeding females sold off the farm each year

Number of employees

- On the farm, Neil, an apprentice one day a week, plus occasional help at busy times







CHAPTER SIX

Conclusions and recommendations

Ensuring the long-term sustainability and resilience of the food system will require nothing short of the most radical transformation of agriculture seen in the last two generations. Achieving this will be a major challenge, but doing so would allow us to harness the potential of farming to help address climate change, reverse biodiversity loss, reduce diet-related disease and improve food security.

This must, however, be considered in the context of short- and long-term solutions. The war in Ukraine, COVID-19 and a potential economic downturn all present serious issues which must be addressed with urgency to prevent famine, poverty and a financial crisis for farmers.

The question then, is how do we respond? We have a choice. We can either continue down the road of industrial farming, producing food that is damaging to our health, the environment and long-term

food security. Or we can look to accelerate the transition to more sustainable, resilient farming systems and, ultimately, ensure everyone has access to healthy, sustainable food.

To enable this transformation, a number of interventions will be required. Perhaps the most important of these is the need to change the way we produce food, and to also align our diets to the productive capacity of the regions in which we live.

Conclusions

LAND USE CHANGE

A UK-wide transition to sustainable farming would dramatically alter the farming landscape and countryside. It would mean a general shift to mixed farming systems, which will be necessary if we are to avoid the use of chemical inputs and restore our soils.

Due to the reintroduction of well-designed rotations including a fertility-building phase, there would be **an increased area under temporary grassland in regions currently dominated by arable production**, particularly in the east of the UK, and **an increase in cropping, fruit and vegetable production in some predominantly grassland areas**, most commonly found in the north and west of the nation.

Other changes in land use, including **an increase in agroforestry, woodland and the area of land used to restore nature**, would create a more diverse and resilient landscape.

Another landscape-scale change resulting from the move to mixed farming would be the **redistribution of grazing livestock across the country**. Whilst numbers would fall in some intensively grazed grassland areas, parts of the country dominated by arable would see an increase, due to their key role in the fertility-building process, amongst other benefits.

These pasture-based systems, including cattle and sheep, as well as free-range pigs and poultry, would replace current intensive livestock systems altogether.

FOOD PRODUCTION

Food production must represent a balance between what the land can sustainably produce and what the population needs to be healthy. In our modelling, the fundamental requirements of biologically-based farming systems (such as the need for diverse rotations including a fertility-building phase), as well as the nutritional needs of society were taken into account, impacting the types and quantities of foods produced.

A greater diversity of crops would be grown, including major increases in the amount of fruit, vegetables and pulses. However, the production of oilseeds and, in particular, sugar beet would decline, as these are at present difficult to grow without the use of synthetic inputs.

Significantly less grain would be produced, with these crops mainly used for direct human consumption rather than as livestock feed. These changes, along with the end of imported protein feeds for livestock, **would result in a significant fall in the production of pork and poultry** — as pigs and chicken are currently heavily dependent on grain and soya for feed.

In contrast, **cattle and sheep numbers would only fall slightly**, though the methods of production would change, **reflecting the critical importance of grazing livestock in sustainable and regenerative farming systems.** The production of **dairy would, however, fall by a third**, due to a decrease in milk yields resulting from a transition to pasture-based systems and a reduction in the amount of grain being fed.

DIETS

Overall, the nationwide transition to sustainable farming would lead to an **increased availability of UK-grown seasonal vegetables, fruit and pulses**, and roughly the same amount of grain-based foods, but from a greater variety of cereals including more oats and rye.

Roughly **the same amount of UK-produced beef and lamb would be available** as today, and about **30% less dairy, all produced from high welfare, mainly pasture-based systems**. In contrast, a transition to sustainable farming would result in **significantly less chicken, eggs and pork — with production coming from free-range systems** with high standards of welfare. Inevitably, these products would become more expensive.

SELF-SUFFICIENCY

Following a transition to sustainable farming, existing levels of self-sufficiency in relation to calories and macronutrients could be maintained and even improved, but only if we ate differently, ate less and wasted less food.

The elimination of imported protein feeds, assumed because of the devastating environmental impacts associated with their production, would also help to reduce the UK's overseas land footprint.

International food trade would remain important in the future, but ideally this should be limited to products that cannot be grown in the UK, or where there are structural deficiencies. Trade should be restricted to products grown to high environmental, animal welfare and food safety standards, in order to prevent UK farmers from being undermined by cheaper imports, often produced to lower standards. Additionally, exports should comprise high quality foods with unique characteristics and provenance.



Recommendations

Enabling a transition to sustainable food and farming systems in the UK would require significant support from government, the financial community, retailers and the public, without which such a change would not be possible.

FARMING PRACTICE

Transitioning to sustainable agriculture would require many farmers to change their farming practices. For instance, the increased diversity of on-farm enterprises associated with a move to mixed farming would require a programme of upskilling and knowledge exchange for farmers and advisors. This would enable the learning of new skills, for instance, around the production of new crops and grazing management where livestock are introduced into cropping systems for the first time.

GOVERNMENT POLICY

To make the necessary changes to farming practice, a range of policies would need to be introduced which collectively support and enable the farming transition, regionally, nationally and globally. This would require joined-up thinking to ensure that educational, economic and trading policies (as touched on below) work together to support the transition.

Agricultural policy would also need to change in a number of ways. **In recognition of the strategic importance of UK food production, we strongly recommend that the agricultural support budget should be maintained, if not increased,** without reducing the budget currently allocated for nature recovery. **Without this, there would not be a strong enough financial case for farmers to make the transition.**

Linked to this, we suggest the introduction of an annual whole-farm sustainability assessment as a condition for the receipt of government subsidies. This is essential to support farmers in improving their practices, and the government to monitor the delivery of public goods. We can only justify the continued use of taxpayers money to support agriculture if we measure the public benefits and illustrate the value to the environment and society delivered by the farming community.

In order for sustainable farming systems to become more profitable than the current extractive agricultural model, the external, hidden costs of food production would need to be reflected in the price of food. Only government can make sure that these costs are properly accounted for, by developing policies and systems of financial support that discourage unsustainable farming practices and encourage sustainable ones.

We also strongly recommend the application of the polluter pays principle to ensure that in future all farmers, land managers and manufacturers of agricultural inputs are financially accountable for any negative impacts their practices and inputs have on the environment and human health.

This would ensure that the most damaging practices are eventually phased out. The application of the polluter pays principle would also play a major part in addressing the problem of dishonest food pricing, which is currently preventing the transition to more sustainable farming practices.

FINANCE

Unless the kind of farming systems recommended in this report are made profitable for farmers and affordable for consumers, a large-scale transition will not be possible. Accordingly, finance schemes which support the transition to sustainable farming systems would need to be introduced, including measures such as discounted interest rates if farmers can demonstrate sustainability improvements, using a common metrics framework.

Private sector investment in farming systems which deliver measurable improvements to natural and social capital would also have an important role to play, though this would need to be properly regulated and should go beyond a simplistic focus on, for instance, carbon, instead taking a whole-farm approach to sustainability.

INFRASTRUCTURE

Enabling the food distribution systems which will best suit the farming transition we are recommending, would require serious investment in local infrastructure.

For example, more local abattoirs and butchers would be needed to support smaller scale and relocalised livestock production, and a greater number of vegetable packing houses in the west of the country would be required to facilitate an expansion in vegetable production.

Parallel investment would also be needed in people and skills to work in and manage such facilities and services. Embracing the principles of the circular economy would also require investment (as well as changes in regulation), for instance in the building of facilities to process food waste safely into animal feed and to compost and recycle abattoir waste.

PUBLIC ENGAGEMENT

There is a large and growing desire among many to support sustainable and ethical food production, however most people remain confused about how they should harness their purchasing power to be part of the solution. **The food sector would need to provide the tools and information to enable the public to make informed choices.** As part of the process of building a consensus around what constitutes a sustainable and healthy diet, education will play an important role. For instance, we recommend that food education should be embedded throughout the school curriculum, and that there be mandatory whole-school approaches to food.

For the public more broadly, **dietary change and reductions in food waste will be key.** Better education about food and farming, improved cooking and preparation skills, alongside increased opportunities for participating in the food system (such as involvement in food growing initiatives), would all help to advance public understanding of these issues. There would also be a need for targeted public campaigns on these issues, supported by the media to help promote key messages.

FOOD MARKETS AND PUBLIC PROCUREMENT

Food companies and retailers have a major role to play in ensuring producers are paid a fair price for their products, and that consumers are given full transparency about where and how the food they purchase has been produced. Supply-chain transparency and commitments around sustainable sourcing would be key to this. **To make it easier for citizens to identify sustainably produced foods, clear food**



labelling, underpinned by a common set of sustainability metrics, would be necessary. Creating markets for local, sustainably produced food would also be vital. Public sector food procurement, in schools, hospitals, prisons and government departments should be centred around seasonal and sustainably produced foods from UK farmers.

INTERNATIONAL TRADE

Transitioning to a sustainable food and farming model has huge implications for international trade. It will be very difficult for UK farmers to produce food sustainably if they have to compete with imports of cheaper foods produced to lower environmental and welfare standards abroad. **Government should therefore set a new framework for trade, based on the sustainability of production,** whereby robust standards are applied to all imports, with any which fall below these being subject to tariffs. Developing a globally recognised set of sustainability metrics would be important in achieving this.

FOOD POVERTY

We are already entering a new chapter in the economy of food, with one in seven UK adults estimated to be food insecure. This represents a major challenge for government.

It is likely that a transition to sustainable farming would result in an increase in the cost of food, which could significantly affect those on low incomes. Therefore, government must act to ensure that every citizen, regardless of financial position, has access to healthy, sustainable food. There are various policy interventions that could be made, including the subsidisation of healthy and sustainable foods for those on low incomes, with revenues provided by the taxation of foods with major environmental and health impacts. **However, these actions would only go so far, and ultimately poverty itself needs to be tackled in order to allow a full and lasting transition to a more sustainable food system.**

RESEARCH

There are potentially huge opportunities for agricultural research and innovation, which if developed, could improve the efficiency, productivity and sustainability of farming practice. This informed our assumption that current organic yields could be increased by an average of 20%, through an increase in relevant research and innovation.

We recommend direct partnerships between producers and researchers, to further research in areas such as soil and animal microbiomes, epigenetics, breeding crop varieties specifically selected for farming systems which use minimal amounts of synthetic inputs, and alternative sources of livestock feed to reduce greenhouse gas emissions.

MEASURING SUSTAINABILITY

Most of the recommendations outlined above will be enhanced and underpinned by sustainability measurements, from the ground up. But until now, there has been no consistent way of measuring the holistic impacts of a farming system. **A growing coalition of farmers, farm advisors, scientists, retailers, financial institutions, government actors and NGOs are now forming behind the need for a common framework for defining and measuring sustainability at farm level.** The outcome of this has been the development of the Global Farm Metric (GFM) — a set of categories and subcategories that measure and define the social, economic and environmental impacts of all farming systems. If adopted, this framework could be embedded into existing farm audits, assessments and certification schemes so that all are aligned and have a common starting point of farm-level data collection.

Ultimately, the most important use of the GFM would be to provide a common language for farm and land use sustainability, which would then inform better understanding, practice and policy.



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Feeding Britain

from the Ground Up