Sustainable Food Trust
A global voice for sustainable food and health

The HIDDEN COST of UK FOOD

Revised Edition 2019

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THE HIDDEN COST OF UK FOOD

FOREWORD

Professor Jules Pretty OBE,
University of Essex

Think of this. Half of all children you know now will live to the 22nd century. They will have adopted sufficient components of healthy living to see them pass a hundred years. Their life journeys will take them through the point where world population will stabilise, then start to fall in some places, for the first time in human history. They will know a world where agriculture, the business of producing food, improves the natural capital of the planet rather than depleting it.

You might observe that this is a rather rosy view of the future, and surely other problems will intervene: political disturbance, climate change, pests and disease, floods. Some of these may represent possible existential threats, many will result in greater temporary hunger and ill-health. But with the expected changes in consumption patterns, combined with population growth, we must hope that year on year, the world's farmers will produce more food from existing agricultural land. Many are already doing so with responsibility and care for environments and people. They are part of redesigned food systems in which healthy food can be grown with respect for nature, and distributed more evenly. There have been many agricultural revolutions across the last ten thousand years of human history. We may be amidst another, and it could be the most important.

Previous agricultural revolutions have brought harm to environments, and often people's health. It did not seem possible, in those times, to conceive of a productive agriculture that did not trade off valuable services from the environment. You want food? Well, stop worrying about the birds and bees, the clean atmosphere and pristine waters, the diverse forests and boggy swamps. Losses are simply the price you must pay to eat. This was the narrative.

Much is asked of agriculture as a single economic sector. Yet it is unlike any other. Earlier models of intensification drew sharper distinctions between wild and farmed lands, between technology and nature, between intensive and extensive. This intensification was premised on the view that agriculture was an economic sector separated from the environment, emerging from the philosophical dominance of a Cartesian view of nature as machine. This led to an assumption of two opposed entities: people with constructed systems of food production, and wild nature out there in the environment.

In the 1980s, Stuart Hill from the radical Hawkesbury College in Sydney and then of McGill University, developed a concept of change in agricultural systems that helps plot both steps towards new and more effective systems, and set a scale for ambition. Hill observed "there is something seriously wrong with a society that requires one to argue for sustainability," and suggested there were three critical stages: i) Efficiency; ii) Substitution; and iii) Redesign.

Efficiency focuses on making best use of resources within existing system configurations. Why waste costly inputs or resources? Efficiency gains include targeting inputs of fertiliser and pesticide to focus impact, reduce use and cause less pollution and damage to natural capital and human health. The first progression is thus from prophylactic, calendar-based and reactive approaches towards problem cure and then prevention.

Substitution focuses on the use of new technologies and practices to replace existing ones that were less effective on both productivity and sustainability grounds. The development of new crop varieties and livestock breeds is an example of substitution replacing less efficient system components with new ones. Beetle banks substitute for insecticides; releases of biological control agents can substitute for other inputs. Substitution implies an increasing intensification of resources, making better use of existing resources (such as land, water, biodiversity) and technologies.

Redesign centres on the transformation of agroecosystems to deliver the optimum amount of ecosystem services to aid food, fibre and oil production whilst ensuring that agricultural production processes improve rather than degrade natural capital. Redesign harnesses agroecological processes such as nutrient cycling, biological nitrogen fixation, allelopathy, predation and parasitism. The aim is to minimise the impacts of agroecosystems on externalities such as greenhouse gas emissions, water quality and biodiversity, while enhancing carbon sequestration and biodiversity.

Redesign is a social challenge, as there is a need to make productive use of human capital in the form of knowledge and capacity to adapt and innovate, and social capital to resolve common landscape-scale or system-wide problems (such as water, pest or soil management).

And this is why this report is timely and important. It shows that current UK agroecosystems still produce considerable environmental externalities. They impose costs on others. We have known the concerns, and now we have some critical data.

We see that we pay for our food three times: first at the till (real or online), second through taxes that provide public support to certain (but not all) types of agriculture, and third to clean up, treat and mitigate the environmental and health costs. For every £1 you spend on food, another £1 is spent through these second and third routes. For the second, this is not necessarily bad: it is progressive to use taxation to ensure transfers from the wealthier to the poorer. Families on low incomes already spend a much larger proportion of their household income on food than those on higher incomes. But everyone is paying for those agricultural systems that are still imposing externalities on others.

This report makes important recommendations. Some are new, some long-standing. At their core is the suggestion that redesign of our agricultural and food systems could be a game changer, setting agriculture on a journey towards sustainability that never ends, but with a clearer sense of multiple food and environmental targets and much wider social benefits.

We know that agricultural and food systems with high levels of social and human assets are able to innovate in the face of uncertainty and farmer-to-farmer learning has been shown to be particularly important in implementing the context-specific, knowledge-intensive and regenerative practices of sustainable intensification. In the end, though, there will be the need to improve values, not just systems of production. And this is where all of society has a critical role to play.

PREFACE TO THE 2019 EDITION

Richard Young, Policy Director, Sustainable Food Trust

This is a lightly revised edition of a report that was first published in 2017. We have corrected a number of errors and reworked a few sections. Some relevant additional research has been published in the last two years, but large gaps in the data still remain, making this not yet the right time for a full reassessment.

We have looked in more detail at the costs of biodiversity loss, food waste and pesticides. We have also added some additional ammonia costs relating to biodiversity loss, as we've come to recognise that this predominantly agricultural pollutant has a wider range of impacts than we previously realised.

Overall this report finds evidence to support a hidden cost for the UK food system equivalent to 96.8p for every £1 spent, compared with the almost exactly £1 for £1 ratio found in 2017.

The purpose of the report is not, however, to put a precise figure on the cost of any individual hidden food system cost, but to give the best indication we can of the likely scale of hidden costs overall. Assessing the costs more and more precisely is something that will inevitably happen over time, but it's a process that will never reach an absolute conclusion.

Our motivation is two-fold:

1. To raise awareness of the extent to which we have been misled by claims that industrial farming necessarily reduces the price of food,
2. To encourage policy makers to make the food system more honest when deciding what sort agriculture to promote and support in future, and when setting fiscal and educational policies which influence the way in which food is transported, processed, retailed and consumed.

Bringing down the cost of food in real terms is seen as one of the great successes of the post-war era. It makes us feel we have more money to spend. This incidentally also helps politicians to get re-elected. As has been pointed out by others, people in poor countries who earn just a few dollars a day spend almost all their money on food. It is one of the few essentials we cannot survive without. In the 1950s people in the UK spent about half their income on food. Today on average we spend 10.5% of our income on food, though for the poorest 20% of the population this rises to 14%. That is a very major change.

Yet today, families on low incomes often find it harder to put food - let alone healthy and nutritious food - on the table than the poorest families did in the past when food was relatively more expensive. There are a number of reasons for this. One of the main ones is that in real terms, housing costs are also very much higher than they were. But another is that we all pay, in ways we hardly notice, a little bit extra here and a little bit extra there, food-related costs, which together add up to a substantial total. These include VAT and income tax, National Insurance contributions, water charges, housing and other insurance premiums, prescription charges, private medical care, medicines bought privately and costs we will pay in future as the longer term impacts of our present, unsustainable food systems increasingly impact on the physical, economic and aesthetic aspects our lives.

This report shows that 'cheap food' isn't actually cheap at all. It may be cheap in the sense that it is not that good for our health, is highly processed, or was produced on a factory farm. But in reality it is a lot more expensive than we realise.

When the first version of this report was published there was reluctance from the farming press to cover the story that the negative costs of the current food system are about as high as the retail cost of food itself. I asked the editor of a major farming publication why they had not run a news item based on our press release and report - he said they had a look at it but frankly didn't believe it.

That is perhaps not so surprising since our estimate of hidden costs (or negative externalities, as economists call them) was £120 billion p.a., while previous estimates from UK academics, including Professor Jules Pretty, who wrote the Foreword to the first edition, amount only to a few billion pounds. So, how do we explain the huge difference?

First, some of the more recent studies we have used include costs for the loss of human life, or the cost of caring for those debilitated by, for example, air pollution or unhealthy diets. These increase costs considerably.

Second, over time, as academics give more consideration to individual issues, they find ways of costing a wider range of aspects, many of which are not entirely obvious at the outset. One example is the European Nitrogen Assessment published in 2011, which put a high cost on diffuse nitrogen pollution, something not even contemplated in the UK's last overall food system costs assessment in 2008. Another is the cost of soil erosion and degradation. The first UK estimate in 1996 came to £24 million a year, whereas the most recent one, from Cranfield University, came up with a figure of £1.33 billion p.a. just for England and Wales. Extrapolating from this, with the help of the lead author, and using a carbon price of £173 per tonne, as we have done throughout this report, instead of the £51 per tonne they had used, gave us a cost for soil degradation in the UK of £3.21 billion p.a.

Third, the report is not simply looking at the negative impacts of intensive farming, it looks at the food system as a whole. More than a third of the costs relate to diet-related disease. Society as a whole can only consume what farmers produce, so agriculture and agricultural policy-makers must bear some of the blame for this. Many foods are also now nutritionally inferior to similar foods in the past, due to the way in which they are produced. Arguably also, at least partly for agricultural policy reasons, not enough land in the UK is devoted to growing fruit and vegetables. But by far the biggest share of the blame must go to those who produce, retail and advertise ultra-processed foods, those who fail to provide a good domestic science education to young people, those who provide accommodation that lacks basic food storage and preparation facilities, and the countless aspects of modern life which have made it harder and harder for most people to obtain modestly-priced fresh food ingredients, or even grow them for themselves.

Fourth, the report also includes an estimate for one postulated damaging effect from the use of organo-phosphate pesticides which is based on less than conclusive evidence. We studied four peer-reviewed papers on this issue and the authors estimate that it is only 30% likely that the small decline in childhood IQ seen EU-wide is related to OPs. There is a theoretical case why there could be a link, but other explanations have also been suggested. However, we felt justified in including a figure for this because there are a very large number of potential costs associated with pesticides, both in relation to human health and the environment, none of which we have been able to include due to the lack of cost estimates - amongst these could be included, for example, the possible link between some cancers and the use of herbicides containing glyphosate.

As we point out in Chapters 4 and 8, we have not included costs for some other areas where costs clearly exist, but reliable data is lacking.

One area where costs could potentially be reduced relates to greenhouse gases. Methane from cattle and sheep account for a high proportion of UK agriculture's emissions. The figures in Chapter 2 were calculated with the commonly-used GWP^{100} method. However, using an improved method recently developed by academics from Oxford University which takes into account methane's short life span, it is apparent that due to the significant decline in cattle and sheep numbers since the mid-1980s, ruminants in the UK have actually been responsible for a small climate cooling effect rather than contributing to warming. This issue is, however, complicated by imported meat. As a result, we have left it for another time.

Major amendments to the cost estimates in the 2017 report

Biodiversity loss – reduced from £12.75 bn to £7.795 bn. The £12.75 bn was based on an EU study estimating global biodiversity loss, which we mistakenly concluded related only to Europe. We have re-examined this issue, see the revised Chapter 3.

OP Pesticides – reduced from £12 bn to £6.4bn. This is because we now have figures for the relative proportion of pesticides used in the UK compared within the EU as a whole. Previously we based this on the proportion of farmland.

Food Waste – increased from £12bn to £19.9bn. We made a slip in the first edition. We based our figures on a WRAP report which estimated that 12 million tonnes of food are wasted at a cost of £19 billion.

PREFACE

Patrick Holden CBE, Chief Executive, Sustainable Food Trust

In the early 1970s I was one of a number of young people who moved to West Wales, with the aspiration of producing food in a more sustainable way. There was growing concern at the time about the environment and what we were doing to it. The Ecologist magazine was in its early years and Friends of the Earth had not long been formed. We were also right in the middle of the 1970's oil crisis, with long queues at petrol stations and there would soon be the first vague rumblings that human activity could be doing irreversible damage to the atmosphere through something called global warming.

Many of us didn't have farming backgrounds but we wanted to produce food in ways that were kinder to farm animals and wildlife, not heavily dependent on fossil fuels and free from both pesticide and antibiotic residues.

There were already a few organic food producers, but there were no legally binding rules or regulations, and little to stop anyone calling their produce organic, however it was produced. There was also no government support for organic farming, no sources of advice, other than the few existing organic producers, and very little in the way of an established market.

Before long the economic realities of running a farm started to compete with our idealism and it became clear that if we were to stay in business we needed to charge higher prices for what we produced because we mostly couldn't make a profit if we sold it at conventional prices.

We wanted as many farmers as possible to convert to organic methods because we felt this was essential for the planet and human health. Yet, because the premium market was necessary for our financial survival we had to define what was and what was not acceptable in great detail. As a result, we ended up creating a 'we' and 'they' culture: either you were on the side of the angels and trying to save the planet, or you were a bad farmer poisoning us all with chemicals.

While the integrity of organic standards needs to be preserved because they describe a more or less complete alternative system that has been proven to work, we also need to find a way for farmers who are unable or unwilling to go organic to move in a sustainable direction; and that's quite difficult because there is very little business case for this at the moment.

But what has really only become clear to me in the last few years is that the reason those of us farming organically need to charge more for the food we produce is because we, to use economic jargon, 'internalize' costs which other producers pass to the environment, future generations and government departments, not least the Department of Health. This occurs because farmers do not have to pay for diffuse pollution and degradation of the air, water or soil, or for the impact on human health of food with low nutritional quality or contamination.

That is the background to this report. There is growing awareness that the current forms of intensive agriculture are grossly exceeding planetary boundaries and that food systems must become more sustainable. But apart from a few green frills, those changes that are occurring are mostly too little and too slow to address the fundamental challenges we face if we are to maintain food security into the future without completely ruining the ecosystems that sustain life.

To some people it may seem inappropriate to put costs on everything. Policymakers, though, rarely take decisions that are not based on hard economics, and they will not be able to develop policies that are in the overall best interests of the public, until they are willing and able to factor in the full costs of both production and consumption.

It may appear that we are criticising food producers. That is not how this report should be read. The food system involves policy makers, regulators, farmers, input manufacturers, academics, educationalists, importers, exporters, processors, retailers and the public, as both consumers and citizens. Each of these can point a finger elsewhere, but in reality, we are all guilty; and in many respects farmers are more victims than villains, as witnessed by the large number of producers forced out of business in recent years by prices which are below the cost of production. Introducing true cost accounting into decision-making is the best and possibly the only way to break the vicious circle which holds us back.

EXECUTIVE SUMMARY

This report finds that the food we eat costs us almost twice as much as appears in our shopping bills.

For every £1 UK consumers spend on food, additional costs of 97p are incurred. These costs are not paid by the food businesses, nor are they included within the retail price of food. Instead they are passed on to society in a range of hidden ways.

In total, production-related costs account for an extra 48p for every £1 spent on food, while the costs of diet-related disease account for an extra 39p.

One surprising conclusion is that farm support payments account for only 2.5p in every hidden £1 spent on food.

Breakdown of every hidden £1 spent on food:

- Natural capital degradation 31.1p
- Biodiversity loss 6.5p
- Production-related ill-health 8.8p
- Diet-related disease 37.4p
- Imported food 7.8p
- Farm support payments 2.4p
- Regulation and research 2.9p

Total £0.97

A high proportion of these extra costs are paid by UK consumers through general and local taxation, water charges and bottled water purchases, private healthcare insurance, and lost income. Others are paid over time to mitigate longer-term impacts such as global warming, ozone depletion, soil degradation and biodiversity loss.

We have been led to believe that we are spending less on food than ever before. As a proportion of income, food prices have fallen significantly. However, in reality, for every £1 we spend on food, we are paying at least another £1 in hidden ways. We can say that with some confidence. While a significant level of uncertainty exists over some of the costs included in this report, many are also recognised to be under-estimates because academics have not yet carried out full economic work on them. This applies, for example, to many as yet uncosted aspects of biodiversity and natural capital loss, to the impact of poor diets on the costs of dementia and the true costs of food imported from regions where rainforest is being felled, soils are being degraded or fossil water is being used for irrigation.

Hidden costs in 2015

UK consumer approximate spend

Food	£86.08 billion
Fruit and vegetable juices and non-alcoholic drinks	£8.44 billion
Catering[1]	£25.62 billion[a]
Total	**£120.14 billion**[b,c]

Hidden food system externality costs

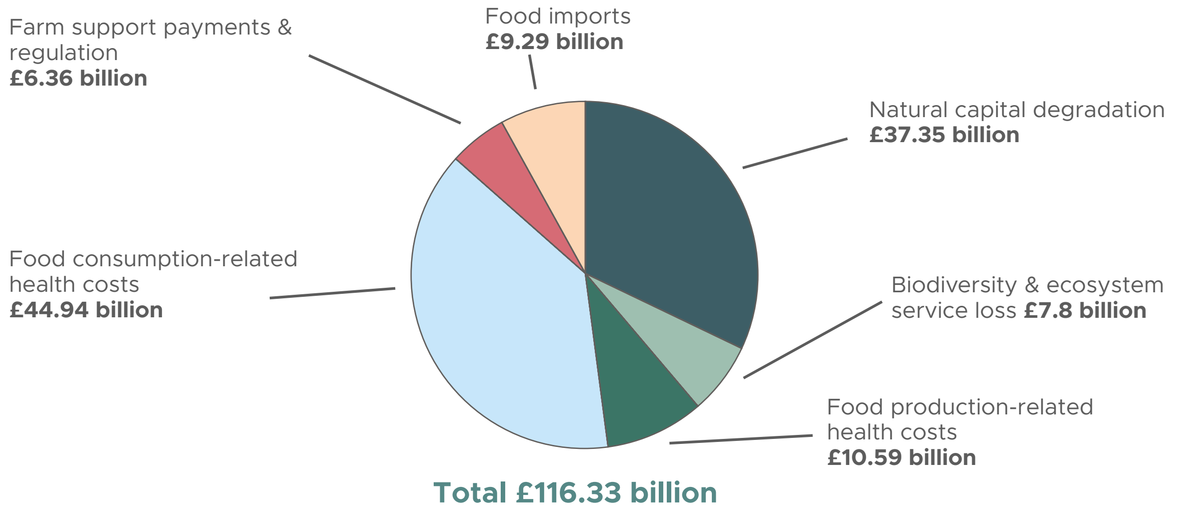
Natural capital degradation	£37.35 billion
Biodiversity & ecosystem services loss	£7.8 billion
Food consumption-related health costs	£44.94 billion
Food production-related health costs	£10.59 billion
Farm support payments and regulation	£6.36 billion
Imported food	£9.29 billion
Total	**£116.33 billion**

a This calculation is based on the assumption that restaurants spend around 30% of their budgets on food, drinks and condiments, so it is appropriate to include 30% of the £85.4 billion spent on catering services – that is £25.6 billion - to actual 'catering food spend' in 2015.

b A commonly cited figure for total UK consumer food spend is £201 billion. For example, a recent paper by Professor Tim Lang and colleagues, 'A Food Brexit: time to get real' (2017) cites the £201 billion figure. This is based on data in the Food Statistics Pocketbook 2015 published in 2016 (which in turn relies on Consumer Trends ONS data), and includes expenditure on alcoholic drinks (£49 billion) as well as all of the catering spend (including labour, overhead costs etc. as mentioned above).

c Some of the costings in this report are based on limited data and must be seen as tentative. However, the total costs calculated are unlikely to be an over-estimate. We have not included any costs for some areas where they clearly exist because there is insufficient evidence to apportion these accurately.

Breakdown of negative UK food system externality costs in 2015



Natural capital degradation

GHG emissions and air pollution	£12.56 billion
Food waste across the total UK food system	£19.9 billion
Soil degradation including soil carbon loss	£3.55 billion
Water costs attributable to agriculture	£1.34 billion
Total	**£37.35 billion**

Biodiversity & ecosystem service loss

Loss of ecosystem biodiversity due to agriculture	**£7.8 billion**

Food consumption-related health costs

Cardiovascular disease, diabetes, cancer and dental caries	£23.08 billion
Malnutrition	£17 billion
Overweight and obesity	£3.86 billion
Hypertension	£1 billion
Total	**£44.94 billion**

Food production-related health costs

Antibiotic resistance	£2.34 billion
Food poisoning	£1.8 billion
Organophosphate pesticides	£6.4 billion
Colon cancer linked to nitrate in drinking water	£43.5 million
Total	**£10.59 billion**

Farm support payments & regulation

Rural Development Programme, administration, regulation and research	£3.35 billion
Basic Payments Scheme	£2.95 billion
BBSRC food and farming research	£56.2 million
Total	**£6.36 billion**

Food imports

Net hidden cost of food imports	**£9.29 billion**[d,e]

d Lacking adequate data, we assume imported food will on average be the same as in the UK. However, we believe this figure is likely to be a significant under-estimate for three reasons; see Chapter 7.

e The cost of the environmental impacts of producing imported food and feed, less the pro-rata costs of producing food we export, which are already included within the natural capital and biodiversity costs above. We have added the hidden costs of palm oil imports to this.

Challenges to be overcome

The Treasury has long required all government departments to assess the non-markets costs associated with policies and programmes. Yet despite a considerable amount of academic work, much of it funded by Defra, and a growing recognition that most food systems in the UK and globally are causing serious environmental, health and social degradation, there has been little fundamental progress in improving the situation. In some respects, systems are becoming even less benign, resilient and durable, creating both immediate negative impacts and long-term threats to food security and public health. To resolve this, two issues need to be addressed.

Firstly, there is currently no business case for most food producers to adopt more sustainable practices. Most food businesses keep their own expenditure to a minimum by passing on the cost of damaging practices to consumers and the environment in hidden ways. In contrast, those who make the greatest effort to farm sustainably generally incur additional costs, and have to charge a premium for food products - thereby limiting the market for them.

Secondly, there is currently no mechanism for assessing the impact of different types of damage caused by food systems. The absence of any such mechanism is arguably the biggest impediment to progress. How – as the saying goes - can we manage what we can't measure?

Addressing the challenges

This report argues that a prerequisite to addressing these challenges is to quantify the scale of the negative impacts of food systems and then to attach financial values to each aspect.

Armed with a full range of costs it then becomes possible to make informed judgement about those approaches which provide the best overall solution for society. Agricultural policy is always set with a close eye on the economic implication of changes. But without a full understanding of the diverse hidden costs associated with food production, it will continue to be impossible to develop agricultural policy and business approaches which promote and encourage food systems with the greatest overall benefits for individuals and society, as measured by both human wellbeing and financial costs.

The purpose of this report

The principal purpose of this report is to increase public awareness of the actual price they are paying for food and to strengthen the hands of those policy makers who recognize that bold solutions are needed and that future food and agricultural policy decisions must be based on a wider understanding of the impacts of food systems than has been the case in the past.

Due to the incomplete nature of much of the published research, the total costs calculated and presented in this report are only initial estimates. Some of the figures may be too high, others too low, and many others have not been included due to the lack of sufficiently reliable data. However, we have strived to make them as accurate as possible within the limitations of existing data.

Agriculture overall has many positive benefits too, and to make an accurate assessment of different farming systems and individual farms, data on the value of the benefits to society from the various aspects of the food system is needed, in addition to the cost of the various negative aspects.

When attempts are made to put financial values on these benefits and those amounts are then deducted from the total negative costs, current food systems can appear to be relatively benign. However, to do this would be to mislead.

First, the positive and negative aspects often do not occur in the same field, or even in the same farm. As a result, taking one from the other tells us nothing about which approaches are most beneficial overall and which are least. Second, where natural capital such as soil is being degraded, there will be a long term negative impact on yields which is rarely reflected in current yield differences between production systems.

We have included a brief overview of these issues (see Chapter 9), but it is outside the scope of this report to attempt an assessment of the financial value of the benefits associated with different approaches to food production. This report focuses on the negative impacts because we want to highlight the potential benefit of giving greater prominence to these issues in agricultural research and policy development.

This report, therefore, attempts to provide a considered estimate of how much we pay for food in ways we do not realise. This will demonstrate how much money is actually being put into the food system by consumers in a shadow economy which most people do not even realise exists, money which could be redirected to greater effect in terms of agricultural sustainability, food security and human wellbeing, without the overall price we pay for food increasing.

Recommendations

Main policy recommendations for the UK Government

1. All aspects of UK agricultural policy post-Brexit should be underpinned by an appraisal of the true costs and benefits of different food production systems and techniques.
2. Public subsidies should be redirected in a way that will discourage environmentally damaging practices, and encourage food systems, practices and foods which bring genuine public and environmental benefits.
3. Consideration should be given to the use of taxes on the most damaging agricultural inputs. A key example could be the introduction of a tax on each tonne of nitrogen fertiliser, with the income raised used to compensate farmers for the additional costs involved in adopting practices proven to increase soil carbon sequestration and storage.

Other key recommendations

Campaign organisations and policy-makers

- Avoid, wherever possible, promoting solutions to single problems and instead recognize the value of integrated approaches and of true cost accounting in establishing which approaches are most beneficial.
- Develop campaigns which encourage businesses and policy-makers to improve transparency around the hidden costs of food production.

Citizen-consumers

- Demand increased transparency from the food industry about the hidden and true costs of food.

Food industry and the business sector

- The retail sector needs to make itself fully aware of the true cost of the food that it sells. In a post-Brexit era, it must be proactive in demanding food and farming policies that ensure its supply-chain partners are producing food that is genuinely sustainable, from the perspective of the environment, farmers and rural communities.
- Support the transition towards better, more resilient and less costly (as per true-cost accounting) practices within the farming industry and the wider food system.
- Increase the mark up on processed foods to reflect their hidden costs to the health system and use the extra revenue to subsidise the costs of high health value foods, so these can be sold at lower prices.

Scientists and researchers

- Undertake research which focuses on outcomes that take account of the true cost of food, updates existing data on the externalities of food production, and fills in gaps in the literature related to food and agricultural externalities, including the wide range of social and cultural impacts.

Funders and investors

- Increase support for projects which aim to research, campaign for and raise awareness about the true cost of food and agriculture, and projects which propose workable solutions to reduce the high cost of negative externalities.

Food producers

- Embrace all current subsidy and other opportunities to make production systems more sustainable and show support for new agricultural policies based on true cost accounting.

1. INTRODUCTION

> *"Call a thing immoral or ugly, soul-destroying or a degradation of man, a peril to the peace of the world or to the well-being of future generations; as long as you have not shown it to be 'uneconomic' you have not really questioned its right to exist, grow, and prosper."*
>
> **'Small is Beautiful' (1973)**
> **E. F. Schumacher**

This report brings together evidence on the negative environmental costs associated with food production in the UK and makes an initial attempt to quantify the cost of the risk factors for diet-related disease that can be linked to poor diets and changes in dietary composition and quality due to current farming methods, as opposed to those factors which relate to poor lifestyles, genetics or other factors. It also undertakes a brief overview of the social and cultural impacts of current food systems and agricultural change, each of which has financial implications, though it has not been possible to attach even crude economic valuations to these due to the paucity of academic research in these areas.

For many years, agriculture was considered solely in relation to its role in producing food, fibres and some fuels, and agricultural economics was associated only with productivity and profitability. John Nix Farm Management Pocketbook, for example, now in its 42nd year, provides food producers with annually updated information about the costs and profitability of different agricultural crops and enterprises, but says nothing about externalised costs.

Over recent decades, however, academics in most (and possibly all) countries have recognized that agriculture also has a wide range of impacts on the environment - some positive, others negative, which are either not reflected in the price of food, or not reflected adequately. Increasingly, attempts have been made to quantify these impacts and to express them in monetary terms, i.e. their actual cost or value to individuals and to society as a whole. This report relies on many of these studies in an attempt to bring together the latest research on these issues.

In addition, rapid changes in food production, processing, marketing and consumption are contributing to the rise in diet-related diseases, the costs of which are placing an increasing burden on healthcare systems and on society in other ways.

Agriculture's uncosted positive benefits, over and above the production of food, include the extent to which some farming systems sequester atmospheric carbon or provide beneficial habitats or food for wildlife, such as crops which provide nectar for pollinating insects or cover for ground-nesting birds. While we briefly review some of these issues, such benefits do not always occur on the same farms as the negative aspects, or necessarily exceed the benefits associated with non-agricultural land uses. Detailing such benefits also requires distinctions to be identified between different production systems and methods, and potentially leads to comparisons between them. While this is what is ultimately required, there is currently inadequate research to undertake this with sufficient precision. As such, in line with the arguments used by Pretty and colleagues in 2005,[2] we have not attempted to include these in our estimates. The primary purpose of this report is to estimate the total value of the negative impacts and therefore the potential benefits for society if these costs were to be reduced.

The reason these issues are important is because the economics of today's dominant food systems are not sustainable. In order to make a living, most producers are forced to exploit the natural capital upon which food production depends in ways that degrade it for future generations. The European Nitrogen Assessment, for example, shows that the negative costs to society from the excessive use of nitrogen fertiliser in food production are up to three times higher than the commercial benefits derived from such use by farmers.

Another obvious example of this is the fact that more than half of all agricultural soils worldwide are now classified as degraded.[3] Degraded soils cannot sustain their productivity.[4] The UK depends heavily on imported food and livestock feed and therefore contributes to this degradation. Soil degradation is also a direct threat to food security. Even though the UK has one of the best climates on the planet to make possible soil carbon sequestration and organic matter retention, the Committee on Climate Change is among those to warn that; 'The majority of agricultural land in the eastern side of the UK is projected to become less suitable for farming due to reduced water availability, increased soil aridity and the continuing loss of soil organic matter.'[5]

A further example is the decline in the populations of pollinating insects in North America and Europe, upon which many food crops depend. This has multiple causes but there is mounting evidence that agricultural pesticides and the practice of growing monocultures on both arable and pasture lands, which has become necessary for commercial survival in the cut-throat world of commodity crop and livestock product production, are two of the more significant.

However, there is another, even less well understood reason: the fact that we have a failed food-pricing system which provides perverse incentives that reward those who intensify and degrade, while discouraging those who want to conserve and enhance. This lies at the heart of the relentless increase in food system scale and intensification; the loss of biodiversity; the shrinking of the agricultural workforce; the exploitation of many of those who work on food processing lines; the pollution of soils, water and the air with agrochemicals and their derivatives. If we look deeply enough we see that this also, in part, lies behind the rise of obesity, type-2 diabetes, many types of cancer and other diseases in the industrial and developing world, as well as the continuing incidence of malnutrition in many of the world's poorest countries.

A handful of headline figures say it all. Globally we have lost a third of our arable land in the last 40 years,[6] and to replace this, virgin land is being converted to food production at an unprecedented rate. The UK depends heavily on imported food and livestock feed and therefore contributes to this problem. Every year 24 billion tonnes of fertile soil is irrevocably lost from farmland due to soil degradation and erosion,[7] 3.4 tonnes for every person on the planet. Between 1990 and 2015, there was a net loss of around 130 million hectares of forest – equivalent to the size of South Africa, and there is an ongoing net annual decrease of 3.3 million hectares of forest every year.[8]

UK soils are losing carbon and degrading due to continuous crop production (Photo: Justin Kase zsixz / Alamy)

All this has grave consequences for wildlife and planetary life support systems. Some estimates put the rate of global species extinction at up to 100,000 species per year, 10,000 times higher than the historical average. In many parts of the world ground water is being extracted at an unsustainable rate for food production, while agriculture is the major source of nitrous oxide and ammonia emissions and a major source of methane and carbon dioxide emissions, the latter principally associated with soil carbon loss.

We are also witnessing the rise of weeds such as black-grass, resistant to all in-crop herbicides, and fungal diseases, such as yellow rust and septoria, which are becoming resistant to all available fungicides. Global antimicrobial use in livestock production is predicted to rise by almost 70% by 2030,[9] at a time when it is widely recognised that it needs to fall substantially to help reduce the rise of antimicrobial resistance; and climate change is starting to test the resilience of current food systems, with an increasing number of extreme weather events around the world causing local food shortages and threatening future global food security.

To a certain extent these problems are the result of the dramatic rise in the global population, which increased from 2 billion in 1927 to 7 billion by 2012. But they also relate to the worst excesses of unfettered and ill-advised agricultural expansion and intensification.

Food systems have many direct and indirect negative impacts, both in terms of damage to natural capital (including soil, water, crop, livestock and wildlife diversity) and human health (from pollution, inadequate or inappropriate nutrition and rising antibiotic resistance). Yet these impacts, or 'externalities' as economists call them, are rarely taken into account by policy-makers and the food industry, while the general public is largely unaware of them.

We urgently need production systems that are more benign, durable and resilient; that use finite resources sparingly; that do not degrade soils or kill off pollinating insects, farmland birds and small mammals, or the spiders and beetles that inhabit healthy soils and provide natural control against some of the major agricultural pests and diseases. We also need food systems that do not pollute the air we breathe or the terrestrial and aquatic environments; that do not cause food poisoning or increase antibiotic resistance; and that produce food and other outcomes which result in overall human and ecological health and wellbeing.

There has long been growing international recognition that current food systems are not sustainable and that things have to change. Yet, while many developments in agriculture have brought genuine benefits and a small number of entrepreneurial farmers have found ways of bucking the system, and in doing so provide us with inspiring examples of more sustainable approaches to food production, the overall trend continues towards ever-greater intensification, specialisation, increasing scale and lack of diversity - each of which make the apparent cost of food cheaper, but its true cost higher.

The question which arises, therefore, is how can we change this, when the average farmer who adopts a more sustainable approach is put at a competitive disadvantage to a degree that can drive them out of business? Some producers bear the cost of using truly sustainable food production systems, while their competitors operate systems that create negative externalities for which they incur no financial penalties. At the same time, consumers who purchase premium-priced food from more sustainable producers are unfairly treated since they too, through taxation and other costs, pay their share of the clean-up costs associated with production systems they do not support.

The problem with hidden costs

In the interests of survival, the majority of food producers have been driven to adopt more exploitative farming practices. The costs of the associated pollution, degradation and over-use of finite resources do not have to be included in profit and loss accounts. Yet many of the costs are in fact paid by consumers, taxpayers and society in hidden ways, through water charges, general taxation (especially VAT, income tax, national insurance contributions), private health insurance and insurance premium tax.

These provide the funding for the cost of farm support payments, environmental, countryside and rural development schemes and agencies, and the clean-up work associated with river pollution and some flooding.

Then there are the treatment and societal costs of diet and environment-related diseases. While it is unclear exactly what proportion of the cost of obesity, type-2 diabetes, cardiovascular disease, cancer and a number of other diseases relate to agriculture or even to diets rather than lifestyle, there is some evidence, which allows initial estimates to be made. It is also clear that many diets are extremely unhealthy. Farmers have to make production choices based on their potential to turn a profit, but any significant reduction in diet-related disease will require encouragement for farmers to increase the production of foods that are better suited for healthy diets.

There are also more intangible costs:

- The degradation of the environment and the loss of the natural capital on which food security and health depends.
- The ever-greater distances people need to travel to find landscapes and unspoilt countryside for leisure and to satisfy aesthetic or spiritual needs.
- The decline in the number of full-time agricultural workers, the increased need for seasonal and sometimes exploited workers and the impact of this on rural life and services.
- The increased traffic and air pollution and health risks associated with increasingly large livestock farms.
- The cost to human welfare and mental health from the declining opportunities to work with farm animals or to farm or grow food oneself on a small scale.

We have been unable to calculate financial costs for these and many similar 'costs' due to the lack of academic research on these issues, yet it is clear that ultimately these do all have costs for both individuals and for society.

The fundamental problem is that because these true costs of the current food system have not been fully assessed and collated, there is no business case for the wider uptake of more sustainable food production. Unless this situation can be changed, the majority of farms will continue down their current path of increasing intensification and greater size, albeit with a little greening in some cases.

In the current system, the polluter does not pay for diffuse pollution or natural capital loss, and producers who adopt more sustainable approaches are rarely rewarded in a way that fully covers the costs they incur, or reflects the savings for society. As a result, the economics driving business decisions are distorted in such a way that the least sustainable systems are generally the most profitable, while the most sustainable are uneconomic, unless they are supported by market premiums or specific subsidies.

As a direct consequence of this, food products from systems that cause the most damage appear to be the most affordable, while more sustainably produced food appears expensive.

This sends perverse economic signals to both producers and consumers. Farmgate food prices are driven down by those adopting approaches with the highest levels of hidden costs. Most producers cannot then even consider making changes to their production methods that might improve their sustainability. They are faced with a stark choice: either continually cut costs through expansion and further intensification, or sell up.

The UK's Natural Capital Committee explains these issues in terms of our failure to distinguish between price and value.[10] In many cases farmers are being forced to degrade the natural capital of their soils and the environment because the price we as a society place on these assets, through the money we spend on food, does not reflect their true value.

Arguably, the most effective way to bring about such a change is for all major food system externalities, both positive and negative, to be accounted for economically, and for agricultural policy, regulation, food business decisions and consumer choice to take them into account. This would result in changes which increase food system health and sustainability and, at the very least, place all production systems on a level playing field.

This report aims to bring to the attention of policy-makers, the food industry, the general public and food producers themselves (many of whom would like to farm in more sustainable ways but cannot afford to do so under the current economic system) the scale of agriculture's unrecognised externalities.

By providing a review of the latest published research on environmental and social externalities related to food production, this report aims to raise awareness about the urgent need to introduce the concept of true cost accounting into food and agriculture policy-making and food business decisions. This would allow the development of a range of economic and policy mechanisms to correct the market incentives which continue to encourage the most damaging food systems.

It will never be possible to avoid all negative costs in agriculture. For example, ruminants, rice production and wetland soils will inevitably continue to emit some methane, croplands will always emit some nitrous oxide and carbon dioxide. But in attempts to mitigate these emissions as effectively as possible, it is essential that policymakers and agriculturalists have access to data on as full a range of true costs as possible so they do not reduce one problem simply by increasing another.

The word 'intensification' in relation to food production is generally used in a derogatory way because most intensification has been based on agrochemicals and practices which produce negative externalities. However, on a planet where the population has all but quadrupled during the lives of some people alive today and seems likely to increase much further, a transition to purely extensive forms of food production would itself create the negative externality of not being able to produce sufficient food. While this report will often use 'intensification' as a shorthand for the most damaging forms of food production, it is necessary to recognise that there are other forms of intensification where many different forms of food production are integrated in agriculturally beneficial ways and total productivity is increased in harmony with the natural world.

Agricultural externalities

In economics, an externality is a cost or benefit that is not paid or accounted for, but affects people or things not directly involved in the activity that gives rise to it. Agricultural externalities are the side effects of agriculture that are felt or accounted for 'externally' to the production system. These externalities can have positive or negative effects on the environment, biosphere, biodiversity, natural resources, human health, and on a range of other issues which affect individuals and society. For example, some farming systems and land management approaches produce food while also having the effect of supporting a diverse range of crops and/or livestock species, wildlife habitats and food sources, sequestering carbon and creating beautiful landscapes – all of which could be considered positive externalities.

Other farming systems rely heavily on nitrogen fertiliser and pesticides, produce food with a very limited range of crops grown in monocultures, or alternatively keep livestock very intensively indoors producing very large amounts of manure in a small area, which becomes an unwanted waste rather than a valuable resource. All this can have alarming ecological, economic, health and social consequences in terms of damage to biodiversity, pollution of air, water and soil, the addition of GHGs to the atmosphere and sometimes also huge demographic changes leading to increased urbanisation and reduced access to land for everyone else in the population.

Agrochemical-based intensification often increases productivity, and in a world with a rapidly increasing population this needs to be recognized as a positive externality. However, there are many other ways of increasing total farm productivity while simultaneously reducing negative externalities and increasing positive ones.

Current yields should also not be seen as the only yardstick by which farming systems are judged. Soils which become degraded will not produce high yields reliably in a world of climate change; and as resources are depleted, food costs will rise in the future because the value of good farmland and input costs will increase. While yields are still increasing in approximately two-thirds of cropland regions globally, they have already peaked in many other areas and have even declined in others.[11] In addition, largely unanswered questions arise about the extent to which changes in the vitamin, mineral and essential fatty acid, and other important micronutrient content of some foods is related to production systems which prioritise quantity at the expense of quality.

While they vary considerably in extent, almost all forms of agriculture (the manual harvesting of perennial crops being a possible exception) have an impact on the environment, since they make use of natural resources and produce some gaseous emissions and nutrient losses. Similarly, many forms of food production also have some beneficial externalities, grassland fields bounded by sympathetically managed hedgerows for example, provide important wildlife habitats and take carbon out of the atmosphere and store it in the soil, even if the grassland is heavily fertilised with synthetic nitrogen and regularly sprayed with herbicides. These impacts are all externalities, but because they are considered side effects of production, their impacts are outside the market and therefore excluded from the final price of the product or goods being traded.

According to Professor Jules Pretty, "When such externalities are not included in prices, they distort the market by encouraging activities that are costly to society even if the private benefits are substantial."[12]

Growing maize for high-yielding dairy cows results in soil erosion which contributed to the Somerset floods in 2014 (Photo: SWNS / Alamy)

The outcome of this is reflected in the price of food, with food produced under exploitative and environmentally damaging systems generally retailing at prices much lower than food produced in less exploitative and more sustainable ways. This is because the external costs associated with damaging production systems are not paid for by producers but are passed on to society in a range of other ways, many and sometimes all of which are not obvious to food consumers. The more sustainable a food system, the lower the negative external impacts will be, and in general the higher the positive externalities.

In the case of organic farming, which is one of the more precisely defined attempts to produce more sustainably, the additional costs of internalising the externalities are often compensated for by increased food prices. However, consumers of organic food are effectively paying twice. They pay through taxes, water charges and sometimes through home and health insurance, like everyone else, to compensate for many of the hidden costs of intensive systems, which in general they do not patronise; but they also pay a premium for the organic food they purchase in order to eat a healthier diet and reduce agriculture's environmental footprint. In addition, the fact that organic food producers have to rely on premium prices, which not everyone can afford to pay, effectively limits the potential for organic systems to expand. Similar constraints apply to Fair Trade, free-range livestock products, local food schemes and foods from entirely grass-fed livestock, as well as to other niche market approaches designed to increase sustainability.

Examples of how society is paying for the negative costs of food production include:

- Charges from water companies - a proportion of which funds the costs of reducing levels of certain pesticides in drinking water below legally acceptable limits and blending water from different sources to reduce nitrate levels below 50 ppm.
- Greenhouse gas emissions - which contribute to global warming, climate change and, in the case of nitrous oxide, depletion of the ozone layer.
- Environmental pollution including:
  - Air pollution by ammonia, hydrogen sulphide, volatile organic compounds and particulate matter from intensive livestock systems.
  - Air pollution from ammonia from the application of ammonium-based nitrogen fertilisers and oxides of

nitrogen from fossil fuel use.

- Aquatic and coastal marine ecosystems pollution and algal blooms due to nutrient enrichment from fertilisers and livestock manures;
- Silting of rivers due, for example, to the cultivation of forage maize associated with higher-yielding dairy systems, which can cause flooding and require dredging, funded through general taxation, and property damage, funded through increased insurance premiums.

- Healthcare costs associated with:
  - Some aspects of diet-related disease.
  - Some skin cancers from ozone depletion in the stratosphere, mainly due to past use of CFC refrigerants.
  - Other cancers associated with the use of endocrine disrupting chemicals, especially those used in many pesticides.
  - Respiratory diseases caused by atmospheric pollution, where ammonia is a major contributor.
  - Some aspects of antimicrobial resistance.
- Social and cultural costs which can be hard to value, but include:
  - Increased transport costs as we travel further to find unspoiled landscapes, rare wildflowers and birds.
  - The decline of rural communities and local economies associated with the exodus of traditional producers driven out of business by larger and more intensive producers.
  - Decreased opportunities for urban and country dwellers to have direct contact with the land, crop production and farm animals. These are part of their cultural heritage, bring therapeutic benefits and arguably have the potential to reduce some mental health problems.

While it may be tempting to consider the net impact of agriculture only, by deducting the value of positive externalities from the cost of negative externalities, they do not always occur in the same field, or even the same farm, and to do this would distort policy assessments. The purpose of this report is to identify the hidden negative externalities in order to inform the development of agricultural policy which will lead to more sustainable production systems. This will simultaneously produce a more diverse range of foods more compatible with healthy diets.

True cost accounting

True cost accounting (TCA), sometimes referred to as 'environmental full-cost accounting' or 'true cost economics', is a system of accounting which ensures that the true costs and benefits of different industries and production processes are properly measured. It has been applied to a wide range of sectors including waste management, food waste, transport, and fossil fuels, as well as to other aspects of society and the economy, such as the social costs of alcohol and the economic and social costs of outsourcing manufacturing to other countries. The concept of value transfer[13] can then be used to correct imbalances, for example by making polluters pay or, for example, by making payments to those who internalise negative externalities or undertake restoration projects.

Since most of the external costs of producing food are currently excluded from the price consumers pay for food, the introduction of true cost accounting into all aspects of agriculture and food systems would enable producers, consumers, policy-makers and the food and farming industry to measure the real cost of the food, both at farmgate and retail levels.

The objective behind the proposed introduction of TCA into food and agriculture is to give policy-makers, businesses and the public the information needed to assess which methods of production, processing and distribution genuinely have the lowest costs to society. Putting economic costs on each externality also allows different externalities to be compared with one another. While initial assessments will inevitably be refined over time, as additional scientific research and economic modelling is undertaken, the expectation, based on analysis of existing data, is that this would make it possible for more sustainable models of food production to be encouraged at the expense of the most damaging systems, which are expected to be those with the highest true costs.

Previous true cost estimates

A number of studies have calculated the cost of individual agricultural externalities in the US, but only one (to our knowledge) has so far attempted to calculate the total costs even of those broadly related to the environment.[14] This study estimated costs of between £4.6bn ($5.7bn) and £13.5bn ($16.9bn) annually, with up to £13bn ($16.2bn) attributable to crop production and £591m ($739m) to livestock. While this is the most comprehensive study to date it nevertheless fails to include all relevant externalities.

Past estimates of the external costs of UK agriculture, principally based on data from the 1990s, have been **£1 billion**,[15] **£1.51 billion**,[16] and **£2.3 billion**[17] **per year**. A more recent study, based on 2004 prices, has estimated that the costs could be as high as **£3 billion, and therefore potentially as high as £4.2 billion at 2015 prices**.[18] The differences mainly result from different approaches.

However, even in the case of the highest past estimate, the authors note, 'For a variety of reasons these estimates are likely to be conservative'.[19] Amongst the reasons given is the fact that at the time there was insufficient data to calculate many of the costs, or calculate them fully. It has also been pointed out that to be really accurate, costs need to be assessed on a 'location-specific basis',[20] but this is not possible due to the lack of sufficiently detailed data.

Two examples of the extent to which the total negative externalities in food systems are likely to have been underestimated come from more recent studies. Studies put the negative costs to society associated with the use of nitrogen fertiliser alone at $157 billion per year in the US,[21] many times more than the total cost estimate of between $5.7bn and $16.9bn for all agricultural externalities cited above.[22] The cost of soil degradation in England and Wales has recently been estimated at up to £1.33 billion per year (in 2015 prices adjusted for inflation).[23] This contrasts significantly with a figure of £14 million annually (in 1996 prices), which was used in a UK study published in 2000.[24]

Since many of the costs relate to human health, large variations between studies can also arise depending on the notional cost ascribed to a human life. The European Commission recommends using a value of between €52,000 and €120,000 per life year but the European Nitrogen Assessment based its calculation on a cost of €40,000 per year.[25] In addition, little academic work has so far been undertaken to apportion the costs of diet-related disease between their many contributory factors including agricultural production method, food processing, advertising and other forms of promotion, insufficient education, personal choice and, one might controversially argue, past nutritional guidelines based on currently disputed evidence.

No academic studies have yet attempted to estimate the total costs of agricultural externalities throughout the European Union as a whole, but the campaign organisation Compassion in World Farming estimated total negative externalities of agriculture in the EU to be just under €170 billion per year.[26]

Note on methodology

The total hidden cost of the UK food system estimated in this report of over £116 billion a year is very much higher than a previous academic assessment made in 2005 of just over £8bn.[27] Inflation and the rising population account for a small proportion of this, but the principal reasons for this much higher figure are:

- We have included a wider range of negative impacts, including many which relate to human health and which can be linked to food consumption (diet-related disease and declining food quality) or food production methods, rather than just food production and distribution.
- We have included data from studies undertaken since 2005, which has broadened the number of issues considered and, in some cases, the number of components taken into account to produce a total for each issue.
- Where our calculations include the cost of carbon we have valued each tonne of carbon emitted to the atmosphere at £173 per tonne, based on a recent assessment which includes some of the wider social costs of global warming.[28]

The use of counterfactuals

Some academics argue that in order for the evaluation of an environmental externality to have meaning, it is necessary to be clear against what it is being judged. This could be changes between one year and another, but they argue that the most meaningful counterfactual is the concept of no agriculture and therefore no negative externalities with which the estimated externalities can be compared. Most of the reports cited in this report do not specifically state what counterfactual they have used. It nevertheless appears to us that most of the studies have tacitly or otherwise used the concept of no agriculture as their baseline, although it is also clear that they have not all used exactly the same methodology.

Harmonising an approach to methodologies, so far as is possible, has long been seen as an important goal. But even if this can be achieved, a wide range of different techniques will still be needed to estimate costs.[29] It is an issue we can only leave to academics to resolve. Ideally the most beneficial counterfactual from our perspective would be to have sufficient data to make meaningful comparisons between different production systems and methods. Such an approach could be within reach and we urge relevant funders and academics to make renewed efforts to gather sufficient data to make this possible.

Level of Accuracy

The robustness of the peer-reviewed and other data on which this report relies varies considerably. Given the incomplete nature of the evidence, our objective is not to establish absolute costs, but to illustrate the likely extent of costs, in order to stimulate renewed interest in this issue and demonstrate why progress towards more sustainable approaches will only be made once policy makers and food businesses take these into account. We also identify areas where further research is needed.

On some issues, the evidence is reasonably comprehensive and up to date, while on others it is incomplete or out of date or both. Where it is out of date but the best available, our approach has been to adjust the figures to 2015 prices, allowing for inflation. A weakness of this is that it fails to reflect changes that may have taken place over time. For example, it is understood that nitrate levels in drinking water, while still high in many parts of the UK, are said to no longer exceed the recommended EU limit of 50ppm because water companies are now able to blend high nitrate supplies with lower nitrate supplies.

The level of accuracy achieved in this report inevitably falls below the highest standards because it looks at an extensive range of issues, each only briefly, and it is limited by the lack of robust UK specific data in many areas. The following diagram illustrates the potential value of studies based on their level of accuracy. We would suggest that our report achieves an overall level of accuracy somewhere in the middle of this range and that it therefore contributes to increasing knowledge and has some potential for influencing policy development, while it clearly falls short of sufficient detail and rigour to be used as a basis for calculating compensatory payments.

Our approach

Where we have evidence that a problem has increased or decreased since the study was undertaken, we have made adjustments where the data is readily available from published sources.

For example we have not included a cost for the impact of Bovine Spongiform Encephalopathy (BSE), which was a significant component of the 2005 study, cited above, because BSE has essentially been eradicated from the UK cattle herd and the ongoing regulatory costs to food producers and processors are largely included in the current cost of beef, while the ongoing costs of regulation and research are largely included in the total government spending on regulation of the food system, which is included in our costs.

We recognize, however, that there may still be some ongoing social costs related to people who were impacted by the crisis either in relation to new-variant CJD or to loss of a business or a job, which we are unable to estimate.

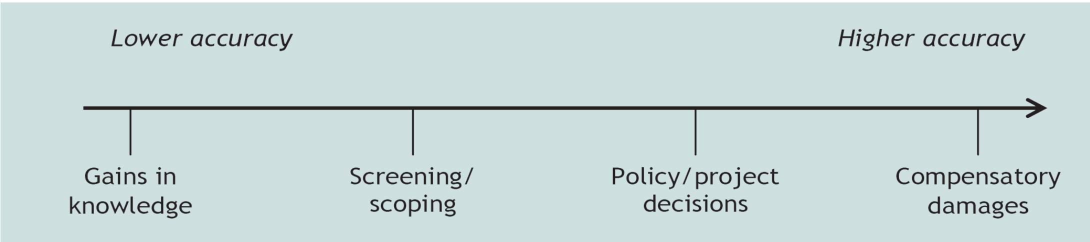


Figure 1: Continuum of decision settings and the required accuracy of a benefits transfer

Where a detailed study provides a range of cost estimates, we have exercised our discretion, but generally used a mid-range and occasionally high-end figure, especially where the authors also note that there are additional costs which they have been unable to estimate themselves due to lack of data, or they have used figures, for example, for the value of a tonne of carbon or a human life year which are below those accepted as reasonable in other reputable studies.

In several cases it has been necessary to estimate the costs in the UK from studies looking at the EU as a whole, where a country by country breakdown is not provided. Here we have based our figures on the UK's share of the farmland area, nitrogen fertiliser use, population or GDP, as appropriate. However, each of these costs may not arise in an entirely pro-rata way in each country and some of these estimates could therefore be too high or too low.

On pesticides and human health, we have used figures from a small group of studies which put costs on the use of one family of pesticides – the organophosphates – throughout the EU. To some these costs may seem very high, but while we are not able to make an independent evaluation of the evidence, we have included these because the authors have undertaken a detailed cost analysis and there is clearly some evidence to support the association they make, even though further research may be needed. We have been unable to include any other costs for the negative impacts of other pesticides on human health due to the lack of economic estimates by academics, even though a significant number of individual studies conclude that there are health impacts associated with some of them.

On diet-related diseases, we have included estimates only where there are studies on the costs and also sufficient evidence to make a meaningful distinction between dietary influences, lifestyle, genetics and other factors. Where we have only a total cost, as for example, with dementia, but no quantified breakdown of the impact of diet compared with other recognised factors such as genetics, lifestyle and smoking, we have been unable to include any costs.

It has also not been possible to include even crude estimates of the financial costs of many other negative externalities associated with the food system. These include the social and cultural externalities associated with the significant and continuing decline in full-time rural jobs, the increasing need for part-time seasonal labour, the increasing size and scale of individual farms, and the corresponding declining access to the land and the opportunity for involvement in food production which many people crave. Some of these issues are nevertheless detailed and discussed.

In relation to farm animal welfare, there are both measurable financial costs and more intangible costs related to the subliminal impact on us of depending on animals living unfulfilling, stressful and sometimes painful existences and/or being transported significant distances to slaughter, and unforgivably, occasionally even maltreated by abattoir staff, themselves under stress by a food system in search of the lowest costs and greatest profit. However, the measurable costs have already been included in the report under other categories, and it is beyond the scope of this report to estimate the value of the more intangible aspects of intensive livestock systems.

We have included the costs of malnutrition, on the basis that these are actual costs borne by society, which arise from the current overall food system. In general, these are not due to a shortage of food but to a range of complex issues which include increased consumption of processed food and reduced preparation of meals from fresh primary ingredients. Some of the issues which are behind these trends are touched on in Chapter 8 on social and cultural externalities and in the section on dementia in Chapter 4.

Although we refer to 'UK' throughout the report, we have not always been able to include Northern Ireland in the data because some figures were only available for England, Scotland and Wales.

Currency conversions

The USD to GBP and EUR to GBP currency conversions took place at various points during the drafting of this report, but principally during 2016. They are therefore subject to some currency fluctuations and due to the fall in the value of the pound against the euro in particular may not reflect current values precisely.

2. NATURAL CAPITAL DEGRADATION

"The value of natural capital and the services it provides are often not well incorporated into decision making processes which rely solely on market prices. As a result, there is too little investment in natural capital overall and its wider benefits are not appreciated."

UK Natural Capital Committee report (2017)

"The decline in natural capital seen over the last 60 years will continue into the future, and is likely to accelerate, unless there is some radical departure from the approaches of the past."

UK Natural Capital Committee report (2015)

Natural capital is the world's stock of natural resources including soil, air, water, mineral deposits and all living things. It can be sub-divided into those resources which are infinitely renewable if managed sympathetically, such as soil, water, the atmosphere and pollinating insects and those which are finite, such as fossil fuels, mineral deposits and arguably antibiotics, anthelmintics (wormers) and pesticides.[f]

Humans derive a wide range of goods and services from natural capital, but have largely taken these for granted. In many situations people can also be viewed as natural capital due to their skills and knowledge.

There is an obvious problem associated with the overuse of finite resources and with the degradation of renewable resources. Modern agricultural systems are heavily dependent on non-renewable resources and also associated with the pollution and degradation of soils, water, air, and biodiversity. Until the full costs of natural resource use are factored into agriculture's balance sheets, this situation is likely to continue.

One of the most graphic examples in recent decades has been the over-exploitation of fossil water reserves in arid regions, which have been used at rates far in excess of natural replenishment,[30] and the over-use of water resources in regions currently suffering from significantly reduced rainfall total, such as California in the US.[31]

Greenhouse gas emissions and air pollution

Costs

A study funded by Defra and the devolved administrations estimated the total cost to society from agriculture-related GHG emissions and air pollution in the UK to be in the region of £2 billion at 2006 prices, £1.4 billion for climate change-related costs and £656 million for the economic damage from ammonia and other pollutants.[32]

The climate change estimate of £1.4 billion is based on a price of carbon of £25 per tonne in 2007. Added to the air pollution figure of £656 million, this gives a total of £2.06 billion in 2007, or £2.57 billion at 2015 prices.

But valuing a tonne of carbon based on the full social impact on human society and the environment is a complex task and estimates for the social cost of carbon range widely, from $21 to $900 per tonne.[33] A recent study by two scientists at Stanford University has estimated that a more accurate figure for the social cost of carbon would be $220 per tonne.[34]

If we take the value $220 (£173) per tonne as a plausible estimate, this increases the climate change estimate to £9.69 billion, which added to the air pollution figure of £656 million, gives a total of **£10.35 billion in 2015**.

In addition to this, the previously cited 2005 study by Pretty and colleagues[35] on farm costs and food miles, estimates the environmental cost of transporting food to homes from retail outlets at around £1.28 billion per year (in 2000). This is based on a UK average of 221 shopping trips per person/year – with most of them (58%) made by car. Although the number of trips for shopping may have dropped due to the introduction of home deliveries, the total UK population has increased by around 8 million. We therefore use the same figure which, adjusted for inflation, is **£1.94 billion** for 2015.

In 2014, 15,419 people developed melanoma skin cancer, 2,459 people died from it and over 100,000 people were living with the disease.[42] Thinning of the ozone layer and exposure to increased ultra-violet B radiation is one of the main risk factors for developing skin cancer and cataracts. The European Nitrogen Assessment (ENA) used evidence indicating that the thinning of the ozone layer due to ozone-destroying chemicals in Europe results in a global health loss of 500,000 disability adjusted life years (DALYs).[43] Using the WHO suggested 1 DALY as equivalent to three times the average national income per capita,[44] the UK's share of this, based on it having 0.88% of the world's population and an average national income of £20,000 in 2007, could be as high as £264 million in 2007 – or £330.4 million at 2015 prices.

Most of the current ozone loss in the stratosphere resulted from CFCs and other persistent halocarbons.[45] Having reviewed a selection of relevant websites[46] and studies,[47] it appears probable that at least one-third of all refrigeration is related to food. As such, for an initial estimate we include one-third of the £330.4 million figure, i.e. **£111 million**.

CFCs and other anthropogenic halocarbons have now largely been eliminated, and nitrous oxide, 75% of which comes from agriculture,[48] is currently considered to be the major source of ongoing ozone destruction.[49] The ENA estimated that for each kilo of nitrous oxide nitrogen released into the atmosphere negative costs of between €1-3 relating to ozone depletion result.[50]

UK agriculture produces 86,600 tonnes of nitrous oxide emissions annually.[51] The molecular weight of N2O is 44 of which nitrogen accounts for 28 or 63.63%. As such, UK emissions of nitrous oxide nitrogen are 54,840 tonnes. The higher figure of €3 per kilo of N2O-N equates to €3,000 per tonne or £2,400 at 2008 prices and £2,880 in 2015. Multiplying £2,880 by 54,840 tonnes gives us a total of £157.9 million. Adding this to £111 million gives us **£268.9 million**.

NITROGEN

Conversion of inert nitrogen in the air we breathe to reactive nitrogen (essentially ammonia, artificial nitrogen fertilisers and oxides of nitrogen) has increased 20-fold over the last century and it is estimated that levels exceed the safe planetary boundary by 350%.[36] Activities and processes related to agriculture – such as fertiliser manufacture, animal manure storage and application, and soil nitrification, denitrification and degradation – make the farming sector by far the largest source of pollution from reactive nitrogen, responsible for approximately two-thirds of all nitrogen pollution of the atmosphere and aquatic environment, while transport and energy production account for one-third between them.

The total annual nitrogen-related damage in Europe ranges between €70 billion and €320 billion, equivalent to €150–750 per person, of which about 75% is related to health damage and air pollution.[37] **The annual cost of pollution by agricultural nitrogen has been estimated to be between €35 billion and €230 billion per year.** The negative costs to society of nitrogen fertilisation in the EU27 exceeds its contribution to the gross value added to the primary agricultural sector by its use, by €70 billion per year.[38]

Nitrogen fertiliser is by far the most commonly used fertiliser and global use is estimated to rise to 120 million tonnes by 2018, with overall fertiliser nutrient use (which includes phosphate, and potash) expected to rise to over 200 million tonnes.[39]

Approximately 3.5 million tonnes of nitrogen fertiliser containing just over 1 million tonnes of nitrogen,[40] or around 9% of the EU27 total, is used in the UK each year. We do not have a detailed estimate of the negative costs associated with nitrogen fertiliser in the UK. As a result, all we can do for now is assume that these costs are broadly similar across the EU and take the mid-point of the cost estimate range. This would equate to €11.5 billion per year in the study year, or approximately £11.88 billion at 2015 prices, in damage to the environment and public health – about £185 per person per year.[41] In this report, these costs are shown under their various categories.

f Strains of weeds and both plant and animal diseases and pests are becoming resistant to treatments of last resort, and there is a critical shortage of new replacement products under development.


Cattle and other livestock are a source of GHG emissions and the main source of ammonia (Photo: Terry Mathews / Alamy)

Background

Agricultural emissions to the air have three separate impacts. Methane, nitrous oxide, carbon dioxide (and the CFC replacement refrigerants) add to greenhouse gases in the atmosphere and contribute to global warming. Ammonia, volatile organic compounds and particulate matter, principally from intensive livestock production but also from the application of nitrogen fertilisers to farmland, contribute to pollution of the troposphere – the air we breathe. Nitrous oxide is currently also the major cause of ongoing ozone depletion in the stratosphere, as detailed above.

UK agriculture is responsible for 10.27% of UK GHG emissions.[52] Given that land use change and forestry in the UK removes 7.4 million tonnes of GHG emissions by sequestering carbon, net UK emissions from farmland and woodland are equivalent to only 8.72% of total UK GHG emissions. However, this does not include emissions associated with imported food, feed and fertilisers produced in other countries, or the emissions associated with fertiliser production, food-related transport, or energy use in the UK which are included in Table 1.

Methane is UK agriculture's major GHG contributing 52.2 million tonnes of CO2 equivalent. Of this, 27.7 million tonnes comes from agriculture with most of that coming from grazing animals and the rest from manure from intensive pig and poultry production. Arguably, the methane from grazing livestock is partially offset by the net carbon sequestration under UK grassland of 7.4 million tonnes. Either way, the figures suggest a very high proportion of the UK's total methane emissions relate to agriculture. This is somewhat misleading since approximately 40% of the UK's energy is now imported and more or less all of this is fossil fuel energy.[g] As a result totals in Table 1 do not include the GHG emissions associated with fossil fuel production and transport. Recent research has shown that these are up to 60% higher than previous estimates suggest.[h]

Table 1: Estimated emissions of nitrous oxide (N20), methane (CH4) and carbon dioxide (CO2) by source category, million tonnes carbon dioxide equivalent (2015)[53]

Sector	N^2O	CH^4	CO^2	Total
Energy supply	1.0	6.7	136.4	144.1
Business	1.3	0.1	68.6	70
Transport (including food transport)	1.1	0.1	118.8	120
Public	0.0	0.0	8.1	8.1
Residential	0.2	0.9	63.4	64.5
Agriculture	16.3	27.7	5.2	49.2
Industrial processes (including fertiliser production)	0.3	0.1	12.1	12.5
Land use, land use change and forestry	1.5	0.0	-8.9	-7.4
Waste management	1.4	16.5	0.3	18.2
Total	23.1	52.2	403.8	479.1

Nitrous oxide (N_2O) is the second largest contributor to agricultural GHG emissions in the UK, and is particularly concerning in the long term because it is very persistent and has a global warming potential of almost 300 times that of carbon dioxide. Nitrous oxide emissions predominantly arise from nitrogen fertilised soils, nitrogen-enriched water and manure storage. Significant emissions also result from the production of nitrogen fertiliser. High nitrogen fertiliser use, conversion of grassland to cropland and soil degradation add reactive nitrogen to the atmosphere as nitrous oxide, increasing global warming. Legumes also enrich soils with reactive nitrogen and some of this is released as nitrous oxide, especially via the urine of grazing livestock or when grassland is ploughed.

Agriculture is also a source of carbon dioxide emissions, most of which comes from the conversion of grassland to cropland and soil degradation associated with continuous crop production and high livestock stocking rates.

Ammonia is a major cause of air pollution but does not contribute to global warming except to a minor extent as a small proportion of it eventually breaks down to nitrous oxide in the atmosphere. The main problem is that it combines with particulate matter and oxides of nitrogen and contributes to air pollution which is responsible for increased rates of cardiovascular and respiratory diseases. Most (80%) of the ammonia emissions in the UK come from agriculture. Of this, 79% comes from livestock (principally when housed), 19% from fertiliser application, and 2% from horses.[54]

IMPACT OF CLIMATE CHANGE

Climate change is already costing economies large amounts of money due to damage from the increased frequency and severity of extreme weather. Left unchecked it is claimed it could reduce average global incomes by about a quarter by 2100.[55]

Global crop yields are estimated to decrease by 15-20% if temperatures rise above 2 degrees Celsius, with the biggest decline expected in Africa and other dry regions.[56]

Declining yields (and agricultural investments needed to guarantee sufficient production) are expected to impact food prices, especially for irrigated crops. In the period 2000-2050, price increases related to climate change are predicted to be 32-37% for rice, 52-55% for maize, 94-111% for wheat and 11-14% for soybeans.[57]

The effects of higher feed prices result in higher prices for meat. For example, it has been argued that grain-fed beef prices would be 33% higher by 2050 if there were no climate change but 60% higher with climate change, compared to prices in 2000.[58]

Food waste

Costs

The global cost of food waste has been estimated to be around $1 trillion annually. In addition to this economic cost – which includes the actual value of the products that are lost or wasted as well as the subsidies that go into producing those products – there are environmental costs of around $700 billion (due to costed impacts on the air, water, soil and biodiversity) and social costs of around $900 billion (due to the costed impact of livelihood loss, health damages, and the impact of conflict).[59]

In the UK, WRAP estimates that 12 million tonnes of food is wasted annually, with an economic value of **£19 billion per year**.[60] This food also contributed 20 million tonnes of GHG emissions, which appears not to have been incorporated into WRAP's cost accounting. A detailed breakdown of the sources of these emissions is only available for household food waste, which accounts for c.17 million tonnes of CO2-eq. when the entire food production chain is examined (the food manufacturing

g BEIS (2016) Digest of UK Energy Statistics (DUKES) 2016, Department for Business, Energy and Industrial Strategy. Available at, https://www.gov.uk/government/statistics/energy-chapter-1-digest-of-united-kingdom-energy-statistics-dukes

h Schweitzke, S., Sherwood, O.A., Bruhwiler, L.M., Miller, J.B., Etiope, G., Dlugokencky, E.J., Michel, S.E., Arling, V.A., Vaughn, B.H., White, J.W. and Tans, P.P. (2016) 'Upward revision of global fossil fuel methane emissions based on isotope database', Nature, 538; 88–91.

Wholesome vegetables can be rejected for minor cosmetic reasons (Photo: Alistair Scott / Alamy)

and agriculture sectors provide much of the rest). Approximately 32% of this 17 million tonnes of CO2-eq. has not been accounted for elsewhere in our report, leaving 5.4 million tonnes of CO2-eq., which using a carbon price of £173 per tonne gives a cost of £934 million. Adding this to the £19 billion gives us an overall annual total of **£19.9 billion**. There is, however, considerable scope to improve this situation, with WRAP finding that between 2015 and 2025 around 20 million tonnes of food waste could be prevented, saving £30-£40 billion and avoiding 60-70 million tonnes of C02 equivalent from being generated. The estimated costs of reducing waste has been put at just 0.6% of the potential savings, or between £200-£530 million.

Background

According to the FAO, approximately 1.3 billion tonnes of edible food is wasted each year globally.[61] This is equal to about 28% of the world's agricultural land in use, has a blue water footprint (the consumption of surface and groundwater resources) of 250 km3, and releases 3.3 billion tonnes of carbon dioxide into the atmosphere annually. Uneaten food is equivalent to the production from about 1.4 billion hectares of land – almost 30% of the world's agricultural land.[62]

Soil degradation

Costs

Over the last twenty years, at least nine assessments have been made of the negative impact of agriculture on soils in the UK. The first of these, in 1996, considered only soil erosion and came up with the very modest annual cost of just £24 million.[63] A subsequent study in 2000 included additional factors such as soil carbon loss and the impact on drinking water increasing the estimate up to £155 million. Further studies have included flooding and additional aspects of soil degradation, such as compaction, with estimated costs of £212 million in 2002,[64] and £620 million in 2008.[65] A 2015 study, from researchers at Cranfield University, is the most comprehensive so far, estimating soil degradation in England and Wales to cost £1.33 billion annually (in 2015 prices adjusted for inflation).[66] This includes values for the loss of agricultural productivity, lost nutrients and the impact of soil degradation on climate change. Half of the cost relates to loss of soil organic carbon.

Yet, even this study has not considered aspects such as the increased impact of droughts and floods where soil organic matter is low, the cost of soil biodiversity loss, the increased levels of crop disease associated with declining soil organic matter, the impact of mineral-chelating agrochemicals on soil and the impacts on human health from declining levels of trace elements in food and the spreading of livestock and human waste containing antimicrobial-resistant bacteria on farmland soils.

Global estimates of the cost of soil degradation have increased from $400 billion per year ($70 per person per year),[67] to between $6.3 trillion and $10.6 trillion annually. This estimate includes erosion, degradation, and the loss of ecosystem services.[68] In Europe, the most recent estimate puts the annual cost of soil degradation at €38 billion per year.[69]

The 2015 figure from Cranfield University of £1.33 billion for soil degradation in England and Wales is currently the highest published estimate. If we assume the same average level of soil degradation occurs on the 7.2 million hectares of farmland in Scotland and Northern Ireland, compared to 11.2 million hectares in England and Wales) we need to increase this to £2.19 billion.[70] In relation to England and Wales the Cranfield study estimates a figure of £570 million for soil carbon loss based on a social cost of carbon (SSC) of £51 per tonne CO2.

The study recognises that this estimate is sensitive to the value placed on a tonne of CO2. Applying the higher SCC figure of £173 tonne of CO2 estimated by the Stanford University researchers (see Note on methodology in Chapter 1) gives us **a total figure of £3.55 billion for soil carbon loss** across the UK.

Erosion is just one consequence of soil degradation, others include loss of organic matter, structure and biodiversity (Photo: Martin Hughes-Jones / Alamy)

This is a rough estimate given the absence of precise data on soil carbon losses for each country in the UK. Rates of soil degradation and carbon loss in each country are likely to be quite different, because a much higher proportion of farmland is under grass, (Wales 90%, Northern Ireland 94%, and Scotland 79%) compared to England (50%).[71] With such a high proportion of farmland – in Wales and Northern Ireland in particular – under grass, it is also likely that the extent of soil degradation will be lower than in England where more farmland is under crop production (in 2015, 33% of all farmland produced wheat, barley and rape for oilseed).[72] Nevertheless, Scotland and Northern Ireland contain a higher proportion of peat-based soils and where degradation occurs carbon losses per hectare could be higher than those in England in particular, because such soils contain significantly higher levels of carbon.

Background

Soil is vital for human survival. Over 99% of human food calories come directly or indirectly from plants grown in the soil.[73] Food security for the global population depends on maintaining soil health to ensure long-term productivity. Soil contains 25% of global biodiversity,[74] over 98% of the genetic diversity in terrestrial ecosystems,[75] and provides habitats for insects, invertebrates, microorganisms and small mammals, many of which are predators of economically significant agricultural pests. It is currently impossible to make accurate estimates of the potential cost to future generations of the extent to which soil life and genetic diversity is being lost or degraded.

Soil also stores approximately 2,500 billion metric tonnes (MT) of carbon - 1,550 billion MT as soil organic carbon. This is essential for maintaining fertility, water retention, plant health and agricultural productivity. This dwarfs the 560 billion tonnes found in plants (including forests) and animals.[76] However, most cropland soils have already lost between 40% and 60% of their organic carbon to the atmosphere as carbon dioxide and ongoing losses continue.[77]

Soils vary considerably in their resilience to modern agricultural methods. In the UK, areas such as the Fens have already lost most of their carbon-rich soils due to several centuries of exploitative agriculture. On some light and sandy soils degradation and erosion are already significant issues. Arable soils with a high clay fraction are more resilient to carbon loss, tending to stabilise after losing 40-50% of their organic carbon. But such soils are easily damaged by heavy machinery, especially during wet conditions.

Globally, more than half (52%) of all soils are now classified as degraded or severely degraded.[78] Such soils are incapable of maximum yields and most eventually end up as deserts. Approximately 1.5 billion people - a fifth of the world's population – are now living on degraded land.[79] Soil degradation also results from salinisation. This occurs for a number of reasons including crop irrigation with water high in dissolved minerals, in areas with high evaporation rates. It is estimated that over the last 20 years an average of 2,000 hectares of productive farmland has been lost every day due to salinisation at an estimated economic cost of $27.3 billion per year.[80]

The loss of soil also facilitates other problems stemming from agriculture. Both phosphate and pesticides are often bound to soil particles and are washed into water when soil is eroded. Such problems could be reversed by changes to production systems. A study comparing a series of low-input organic crops to intensive production found that soil aggregate stability was up to 60% higher in the low intensity environments.[81]

Soil is also a major component of the carbon and nitrogen cycles. Whether or not its management contributes to global warming through net emissions of CO2, N2O and/or CH4, or to climate change mitigation through net sequestration of carbon, minimal emissions of N2O and the removal of small but significant amounts of atmospheric methane by healthy populations of methanotropic bacteria, largely depends on the management strategy adopted. Soil degradation adds carbon and nitrogen to the atmosphere, principally as carbon dioxide (CO2) and nitrous oxide (N2O).

Water

Costs

A range of different cost estimates have been made in relation to external costs associated with agriculture and water. These include:

- Groundwater - £51-89 million per year[82]
- Nitrate removal from drinking water[i] - £48.7 million,[83] roughly equivalent to £61 million in 2015 values
- River ecosystems and habitats - £37-65 million[84]
- Treatment costs to remove pesticides - £34.7m; and *cryptosporidium* - £22.8 million[85]
- Eutrophication - £20-33 million per year[86]
- Removing sediment from drinking - £22.8m[87]

Sediment in waterways also adds to the total bill by: clogging up water filters and discolouring water; reducing the capacity of reservoirs and therefore leading to additional costs of dredging and building new capacity, as well as potential impacts to recreational activities such as fishing – estimated to be as high as $3.2 billion in the US in 2002;[88] and blocking road-side ditches and irrigation canals – with costs estimated to be as high as $790 million (in 2004) for removing sediment to prevent flooding.[89] Eroded soil also increases the likelihood of flooding and settles on property in the aftermath of floods. A 2002 estimate of flood damage in the United States due to cropland erosion is between $343-812 million (or almost $1.09 billion today).[90]

According to National Farmers' Union Mutual, which insures 75% of UK farms, Storm Desmond caused £20 million worth of damage to farms and rural businesses in December 2015.[91] Floods on the Somerset Levels in 2014 resulted in £18.9 million worth of damage according to Defra,[92]

High use of fertilisers results in eutrophication of waterways and loss of aquatic life (Photo: geogphotos / Alamy)

i It is unclear what, if any, costs are currently being incurred by water companies in relation to nitrate.

The true cost of nitrogen fertiliser use is three times greater than its commercial benefit to farmers (Photo: Gary Naylor)

while the NFU claimed the cost of the 2013-2014 floods could rise to £100 million for farmers.[93] The summer floods of 2007 affected 42,000 hectares of UK farmland and the total cost of damage (including damage to households, businesses, roads, and power and water utilities) was estimated to be approximately £3.2 billion.[94]

A study commissioned by Defra estimated the annual value of flood damage attributable to agriculture to be worth £233.8 million in 2007, equivalent to around £0.29 billion in 2015,[95] but the costs of flood damage could well increase in the near future.

The most complete study we have found estimated the cost of the total environmental damage in England and Wales from agriculture to water to be as high as £872 million in 2004 prices – equivalent to £1.2 billion in 2015.[96] This figure included the impact of poor water quality on recreation and natural habitat, as well as surface water treatment costs by water companies. However, we do not include their figure for nutrient polution in lakes, as this area is included in the following chapter (see Chapter 3 for explanation), meaning we use a total here of £1.05 billion per year.

Adding the £1.05 billion for environmental damage to the flood damage figure of £0.29 billion cited above, produces an overall figure of around **£1.34 billion for water-related costs from agriculture each year**.

Background

Water is essential for agriculture, but poor management and short-term thinking has left many vital water sources depleted or contaminated. With 70% of the world's freshwater sources now diverted for agriculture and 21 of the world's 37 major aquifers having reached their sustainability tipping points,[97] there is mounting concern about the need to conserve water for future use.

Water pollution by agriculture leads to algal blooms in rivers and lakes due to high nitrate and phosphate runoff from fertilisers. These excess nutrients have a huge impact on marine and riverine ecosystems, with more than 245,000 square kilometres now classed as 'dead zones' globally,[98] translating to a loss in ecosystem services worth billions of dollars.

Nitrogen use in agriculture also has a significant impact on groundwater pollution, resulting in additional impacts on public health related to elevated nitrate levels in water. Nitrogen enters drinking water from fertilisers, livestock waste and mineralisation of organic nitrogen in the soil. High levels of nitrate in the water system have been linked to colon cancer and other illnesses (see Chapter 4).

In addition to the direct impacts of agriculture on water systems, there are the indirect impacts of increased droughts, floods, changes to traditional weather patterns, pests and pollution linked to climate change which are likely to restrict and disrupt global agriculture. Farms in the UK have suffered from severe flooding in recent years, and climatologists have shown that climate change has increased the risk of extremely wet winters in southern Britain by 25%.[99]

3. BIODIVERSITY LOSS

"The intensification of agriculture has had the biggest impact on wildlife, and this has been overwhelmingly negative. Over the period of our study (around 40 years), farming has changed dramatically, with new technologies boosting yields often at the expense of nature."

State of Nature 2016 report

Biodiversity is a component of natural capital which we cover separately in this chapter due to its importance and complex nature.

Loss of ecosystem biodiversity due to agriculture

Costs

The UK National Ecosystem Assessment 2011 concluded: 'The natural world, its biodiversity and its constituent ecosystems are critically important to our well-being and economic prosperity, but are consistently undervalued in conventional economic analyses and decision making'.[100]

Biodiversity has been defined as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."[101] As well as having enormous intrinsic value, there is increasing evidence to show that biodiversity is fundamental to the provision of ecosystem services, which are "the benefits provided by ecosystems that contribute to making human life both possible and worth living".[102] Because the two are so closely interlinked, biodiversity and ecosystem services have often been considered together in valuation frameworks. We follow this approach here, although GHG emissions, soil degradation and most water pollution costs are covered in Chapter 2. The biodiversity benefits from agriculture are also considered in Chapter 9.

Maintaining a healthy environment is clearly of vital importance to human wellbeing. This has been increasingly recognised in governance circles over recent decades, culminating in the UN's Strategic Plan for Biodiversity, agreed in Aichi in 2010, from which national biodiversity targets were set. Despite some progress, the Strategic Plan has largely failed, especially in more developed countries like the UK, where only 5 of the 20 targets are on course to being met by 2020.[103] With 25% of all animal and plant species believed to be threatened with extinction globally,[104] there is an urgent need to place biodiversity higher up the policy agenda.

There are legitimate arguments around whether the natural world, essential for both our physical and spiritual needs, should be monetized, not least because once valued, developers could potentially pay to be allowed to destroy it. Quantifying the financial value of biodiversity and ecosystem services nevertheless represents a potentially important means of reducing biodiversity loss. At the present time biodiversity continues to decline in part at least because no financial value is placed on it.

While gathering sufficiently reliable data to produce a fully comprehensive analysis is an enormous challenge, a number of efforts have been made in recent years to value individual components of biodiversity and to make global estimates. Various approaches have been used to calculate costs, perhaps the most common being questionnaires and choice experiments from which the amount of money members of the public would be willing to pay for some aspect of biodiversity can be ascertained. These so-called stated preference methods are particularly useful as they enable any aspect of biodiversity, including difficult-to-quantify values, like the innate worth of a species, to be considered. While these can be used to put a nominal value on the loss, for example, of a rare orchid, they nevertheless have shortcomings when it comes to valuing the loss of ecosystem services, such as pollination, or a less than charismatic species, such as stag beetles which when they have sufficient habitat help to control slugs, hence avoiding the water and wildlife pollution associated with the use of molluscicides. For further discussion of methodology see, for example, Defra's Valuing Biodiversity discussion paper.[105]

The global analysis carried out by Costanza et al. (initially in 1997 but updated in 2014) is the best-known attempt at valuation of ecosystem services. These were estimated to be worth $125 trillion p.a. in 2011, considerably greater than the global Gross Domestic Product (GDP) in 2011 of $75 trillion.[106] In relation to the UK specifically, there have now been a number of estimates, ranging from individual components of biodiversity to more comprehensive national analyses. For instance, McVittie and Moran estimated a value of £890 million - £1.7 billion p.a. for the benefits provided by marine conservation policies.[107] On land, the biodiversity benefits generated by the UK Biodiversity Action Plan have been valued at £1.366 billion p.a., with the public willing to pay an additional £746 million p.a. in a scenario where UKBAP measures are strengthened. The most highly valued services are water and climate regulation, followed by charismatic species and then sense of place.[108] Using similar methods, it has been estimated that the public is willing to pay £956 million p.a. for the benefits provided by Sites of Special Scientific Interest, plus another £769 million p.a. if all were in a favourable condition – considerably more than the £111 million spent p.a. in SSSI management costs.[109] Although large, these values may nevertheless be underestimates: the Natura 2000 network of designated sites (which includes SSSIs) has been estimated to have a value across the EU of €200-300 billion p.a. In area terms, the UK contains 4.4% of this network, so if we apply this proportion to the financial estimates, that would suggest a value in the UK of €8.8-13.2 billion, or £7.81-11.71 billion p.a. (this, of course, assumes that the EU-averaged per hectare values can be transferred to the UK). In terms of the role agriculture plays in supporting biodiversity and ecosystem services, O'Neill (2007) estimated a value of £1.455 billion p.a. in 2004 prices, thanks to the amenity services landscapes provide, provision of habitats and species, and carbon sequestration,[110] while Defra's environmental accounts estimate a value of £1.197 billion p.a. through provision of habitats and farmland birds: both of these valuations are considered significant underestimates.[111]

Valuations of the costs incurred from biodiversity and ecosystem service loss are more difficult to find. A study conducted for the European Commission estimated that global biodiversity losses from terrestrial ecosystems alone equated to €50 billion in 2000. However, this was considered an underestimate as it did not take into account the decline of several important ecosystems (e.g. coral reefs and wetlands), used conservative estimates of land-use change, and did not consider the potentially catastrophic impacts incurred once ecological tipping points have been exceeded.[112] Costanza et al. (2014) produced a much larger figure in their global valuation, with annual costs due to habitat loss of $4.3-20.2 trillion p.a.: these figures have faced criticism both for being too high and too conservative.[113]

We have only come across a handful of studies which estimate biodiversity damage costs from agriculture in the UK. While these are all ground-breaking and extremely useful studies, the authors point out that their total cost estimates are not comprehensive, since data was lacking in many areas, and this has still only been partly corrected today. Pretty et al. (2000) produced a figure of £150.3 million p.a. in 2000, which was calculated using the estimated costs

Increasing field size, monocultures, pesticides and fertilisers all contribute to biodiversity loss (Photo: Gary Naylor) of reinstating priority habitats and species, reinstating hedgerows, and the economic impact of lost beehives.[114] This cost is almost certainly a major underestimate. Other estimates include those from O'Neill and Defra, which found total environmental costs of £2.615 billion and £1.149 – 3.05 billion respectively. GHG emissions and air pollution are the largest costs in both reports (accounting for 64% and 79% of the cost totals respectively) while damage to the freshwater environment constitutes most of the remainder (29% and 11% respectively) principally from poor water quality in rivers and water treatment costs. These costs have been considered in Chapter 2 of this report. Again, these are almost certainly major underestimates, as many areas of damage are not costed (e.g. the impact of pesticides on the environment), while those that are, tend to be limited by a lack of data or only relate to certain areas of the UK.

Costings produced by the European Nitrogen Assessment (ENA)[115] and Van Grinsven et al. (2013)[116] on the environmental and health impacts of nitrogen application perhaps highlight how conservative some of these UK biodiversity damage costs are. By applying the unit damage costs used by the ENA and Van Grinsven et al. to air- and water-borne nitrogen emissions in the UK (€5-20 per kg of nitrate N, and €2-10 per kg of NOx and NH3 N), we can calculate costs of £1.32-5.32 billion p.a. due to agricultural nitrate pollution in freshwater and marine environments, £434.3 million-2.17 billion p.a. due to agricultural ammonia emissions reducing species diversity in terrestrial habitats, and £15.33-76.63 million p.a. due to agricultural NOx emissions (principally from the use of diesel in agricultural tractors), coming to a total of £1.769-7.567 billion p.a. in environmental damage costs from nitrogen use in the UK (the wide range in costs reflects

Loss of feed sources due to intensive cultivation has caused corn buntings to decline dramatically. (Photo Adobe Stock)

methodological constraints and widely differing impacts depending on e.g. geography and habitat type, amongst other factors). These costs are massively higher than equivalent UK estimates: for instance, Defra and O'Neill estimate costs from eutrophication to be only £27 million p.a. and £33 million p.a. respectively (though they do recognise that these are likely underestimates), which pale in comparison to the £1.32 – 5.32 billion p.a. in nitrate damage costs calculated using ENA methods, much of which relates to eutrophication.

So far, attempts to value the environmental damage incurred by agriculture in the UK constitute a very useful starting point, but it is apparent that the total cost estimates they have generated are too conservative, due to methodological issues, lack of data and a failure to include all aspects of biodiversity loss. Costs relating to GHG emissions, soil degradation and water pollution are treated elsewhere in this report, so the best we can do here is take Pretty et al.'s figure of £150.3 million (£228 million p.a. in 2015 prices) and add this to the £7.567 billion p.a. in environmental damage costs from nitrogen use, to come up with an indicative cost of **£7.795 billion p.a.** We use the upper nitrogen cost estimate here to reflect the lack of costings available for other negative environmental impacts from agriculture (e.g. pesticide use and habitat loss, and the loss of seemingly minor species which it is slowly being realised play a variety of crucial roles in both ecosystems and food system productivity). Costs relating to eutrophication are included here, instead of the water pollution section. If we were to include the report's other costs relating to loss of ecosystem services and biodiversity (from GHG emissions, soil degradation and other aspects of water pollution) this would add a further £14.1 billion p.a. to this section. It is clear, therefore, that as well as providing considerable environmental benefits, UK agriculture is also associated with hugely significant costs in relation to biodiversity and ecosystem services decline.

Background

It is widely accepted that the loss of biodiversity has largely been caused by modern agricultural production methods in tandem with the rising global population. This has led, for example, to the loss of rainforest in South-East Asia for palm oil production and rainforest and other virgin land in South America for soyabean production.

In the UK we have seen the loss of natural habitat, including removed hedgerows and the loss of species-rich pasture including traditional hay meadows. It is estimated that between 1930 and 1984, 97% of enclosed semi-natural grasslands were lost through intensification or conversion to arable.[117]

While agricultural intensification has increased crop yields, it has also led to a decline in crop and livestock diversity. This in turn has impacted on wildlife, in terms of both in-crop habitat loss and greatly reduced continuity of food supply. With the exception of organic and some low input farms, the use of integrated crop and livestock rotations has been almost entirely replaced by monoculture cropping, principally with wheat and oilseed rape, which increases profits, but tends to require higher use of herbicides, insecticides and fungicides, each of which has been shown in studies to have negative impacts on wildlife. In addition, because ecosystems have been thrown out of balance, natural predators like soil spiders, beetles and hedgehogs, which are all beneficial in controlling some common crops pests and diseases, have suffered a major decline in numbers. This has resulted in yet greater use of fungicides and insecticides than would otherwise be necessary.

High pesticide use is particularly concerning from the point of view of insects, which have been estimated to provide an ecosystem service value of $57 billion p.a. in the US alone.[118] Worryingly, a recently published long-term study in Germany has found that flying insects may have declined by as much as 76% over the last 27 years.[119] This has raised widespread alarm since insects play an irreplaceable role in many of the ecosystem services upon which humans depend, such as pollination, the breakdown of animal manures and plant material, and other aspects of nutrient cycling. Studies also show that 80% of wild plants depend on insects for pollination[120] and 60% of birds depend on insects for food[121].

There has been widespread coverage of the debate relating to the impact of neonicotinoid insecticides and declining pollinator numbers, and the potential economic impacts of this, as well as the increased losses described in the State of Nature 2016 report quoted above. However, the focus on this one group of pesticides, though important, has tended to overshadow a broader understanding of other changes in agricultural practice which are also likely to be involved. See Appendix 3 for further details on insect pollination, pesticides and monocultures.

The Pasqueflower is now endangered due to the conversion of lowland grassland to cropland. (Photo Adobe Stock)

Fields and farms have also greatly increased in size at the expense of hedgerows, other boundaries and habitat features which have been removed. Natural habitats have become fragmented, making farmland a hostile environment for many wildlife species, impacting natural cycles including seed availability, nesting and hibernation patterns for birds and small mammals. The State of Nature report published in 2016 shows how between 1970 and 2013, 56% of 4,000 land and freshwater species declined – 40% with 'strong or moderate declines'.[122]

Agricultural intensification negatively affects the population of birds, particularly farmland birds.[123] These play a vital role in agro-ecosystems through insect pest control, pollination and seed dispersal. Even though only 1.3% of bird species became extinct between 1500 and 2000, the global number of individual birds is estimated to have experienced a 20–25% reduction during the same period, indicating that avian populations and dependent ecosystem services are declining faster than species extinctions would indicate.[124] The Royal Society for the Protection of Birds found that in 2008, pesticides in the UK were behind significant declines in grey partridge, corn bunting, yellowhammer, turtledove, yellow wagtail, sparrowhawk, stock dove, and skylark.[125]

The 'Biodiversity Intactness Index'[126] puts the UK below the Planetary Boundary for biosphere integrity (at 81%, below the global average of 84.6%), and ranks it 189th out of 218 countries for which estimates are available.[127]

4. FOOD CONSUMPTION-RELATED HEALTH COSTS

> *"Was there one thing that happened that could explain the sudden and dramatic increase in obesity? Yes, there was. In 1977, the USA changed its public health diet advice. In 1983 the UK followed suit. A more accurate description would be that we did a complete U-turn in our diet advice from 'farinaceous and vegetable foods are fattening, and saccharine matters are especially so' to 'base your meals on starchy foods.' Obesity has increased up to ten-fold since – coincidence or cause?"*
>
> **'The Obesity Epidemic: What caused it? How can we stop it?'**
> **Zoë Harcombe**

> *"The destiny of nations depends on the manner in which they feed themselves."*
>
> **'The Physiology of Taste'**
> **Jean-Anthelme Brillat-Savari**

It is increasingly recognised that there is a huge cost to society from diet-related disease. We have estimated costs in this section under commonly recognised diet-related disease headings, based on the best available evidence we could find.

We refer to this as 'food consumption-related disease' to distinguish it from food production-related disease and ill-health. But not all the costs relating to dietary issues are due to poor consumer choice. As detailed in the following chapter, changes in the nutritional quality and purity of foods otherwise considered to be part of a healthy diet also influence the risk of developing diet-related diseases.

Examples include, production and processing methods which influence the balance between the two groups of essential fatty acids, the levels of antioxidants and level of B-vitamins in food, and possibly the levels of antibacterial substances which affect the microbiome, which together influence the risk of developing most, if not all, the diseases detailed in this chapter.

Given the lack of good economic data on diet-related health costs, as well as the difficulty of calculating the exact contribution of diet to a wide range of illnesses, this section of the report comes with a caveat: that the diet-related and environmental health costs are rough figures and the main purpose of this section is to highlight the likely scale of these costs as well as the research gaps that need filling in.

Cardiovascular disease, diabetes, cancer and dental caries

Costs

A 2005 study estimated the total cost of diet-related ill-health in the UK at around £6 billion. This was based on data from 1992-1993, with an assumption that about one third of the overall disease burden (measured in disability-adjusted life years) is attributable to food related diseases.[128]

An updated study in 2011,[129] estimated that diet-related ill health in the UK cost the NHS £5.8 billion, or about 6% of total NHS costs in 2006-2007 which were around £94.5 billion.[130] This estimate is made up of costs due to:

- Cardiovascular disease - £2.5 billion, 9.2% of total NHS costs;
- Type 2 diabetes - £0.8 billion, 2.8% of total NHS costs;
- Cancer - £1.7 billion, 6.2% of total NHS costs (interestingly we arrive at the same figure if we extrapolate from another study - see box on cancer);
- Dental caries - £0.9 billion, 3.4% of total NHS costs.

Total NHS spending in the UK during 2014-2015 was £135 billion.[131] If we take 6% of this it equates to £8.1 billion in 2015. While the authors of the 2015 report were careful to distinguish between diet-related costs and other factors they only calculated the direct costs to the NHS. They did not include the broader costs to society from lost productivity and increased care costs.

CANCERS

In the UK, there are over 350,000 new cases of cancer every year, and 42% of these are considered preventable.[132] It has been estimated that annual costs to the NHS for cancer services are in the region of £5 billion, with a wider cost to society (including the costs associated with loss of productivity due to cancer) of £18.3 billion.[133] The incidence of cancer is linked to diet and a wide range of other factors.[134]

A study in the British Journal of Cancer estimated that diet-related factors (including relative consumption levels of fruit and vegetables, meat, fibre and salt) could be attributed to 9.4% of all cancers.[135]

A study relied upon by Diabetes UK for its 2014 report on 'The Cost of Diabetes', estimated the cost of diabetes in 2010/11 to be £23.7 billion of which £21.8 billion related to type-2 diabetes (£8.8 billion for direct costs and £13 billion to indirect costs).[136] That is, the indirect costs were considerably more than the direct costs. Given that the incidence of new cases of type-2 diabetes and the number of people affected continues to increase, and that improving diets is seen as the major way to reduce the risk of type 2 diabetes, we feel that even adding

Diets need to change significantly in order to stem the rising incidence of type-2 diabetes (Photo: Biologycorner / Flickr)

additional costs of £13 billion, or £15.04 billion in 2015 adjusted for inflation, to the cover the indirect costs associated with type 2 diabetes, cardiovascular disease and the impact of diets on the incidence of certain cancers under-estimates the likely costs here. However, this gives us a total of **£23.14 billion** (£8.04 billion combined with £15.04 billion).

Background

Unhealthy diets are the top factor driving ill-health in the UK, accounting for over 10% of the total disease burden, closely followed by tobacco smoking.[137] Approximately 40% of NHS resources are spent on potentially preventable illnesses related to dietary patterns, smoking, alcohol consumption and obesity.

Malnutrition

Around 2 billion people suffer from malnutrition globally. It is estimated that this costs the global economy $3.5 trillion per year, and that undernutrition and micronutrient deficiencies cost up to $2.1 trillion per year.[138]

In the US, the Bread for the World Institute estimated the total costs attributable to food insecurity at $179 billion in 2014, costs which include education and food assistance, as well as the health costs related to diabetes, mental health, osteoarthritis and loss of work time.[139] The annual burden of disease-associated malnutrition has been estimated at $157 billion in 2014, or $508 for every US resident.[140]

In the UK, it was estimated in 2005 that more than £7.3 billion was spent on treating malnutrition annually.[141] This was made up of £3.8 billion for treating malnourished patients in hospitals and £2.6 billion for similar treatment in long-term care facilities. Other costs related to £490 million for GP visits and £360 million for outpatient visits. In addition, a further £5.3 billion was spent on long-term care and intensive nursing.[142] It is not clear whether the situation has improved, stayed the same or deteriorated further since 2005, but the serious malnutrition mostly affects the elderly and the proportion of elderly people in the UK has increased since 2005 from around 15% of the population to 17%.[143] The report argued that even slight improvements in nutritional care within the public health service could produce significant financial returns.[144] Taken together these costs were £12.6 billion in 2005, equivalent to **£17 billion in 2015**, though a more thorough analysis would need to ensure there was no double accounting here in relation to some costs associated with type 2 diabetes, dementia and antibiotic-resistant infections.

Overweight and obesity

Costs

Obesity has been estimated to have a global economic impact of around $2 trillion annually, or 2.8% of global GDP.[145] In the US, healthcare costs of obesity were around $170 billion in 2008, but it is estimated that they could be as high as $344 billion by 2018, equivalent to 20% of annual medical spending.[146]

A report by the McKinsey Global Institute estimated the annual economic impact of obesity in the UK (including lost productivity due to disability and death, and the costs of health care) to be $73 billion (£59 billion) in 2012, approximately 3% of the UK's GDP,[147] making it the second largest health liability – after smoking – of the UK economy. This would be roughly equivalent to £62.8 billion in 2015 adjusted for inflation. We chose not to use this figure as part of our total costings because it is not possible to tell from the report which of the illnesses which obesity makes more likely have been included in their total, and how much has been associated with care costs in the community or lost productivity due to disability and death.

Instead we rely on a more detailed analysis by Scarborough and colleagues in 2011,[148] also referred to in the section above on cardiovascular and other diseases. The authors estimate that overweight and obesity, which they associate with increased risk of conditions such as heart attacks and osteoarthritis, cost the NHS £5.15 billion in 2006-7, or £3.03 billion if we exclude hypertensive disease which is covered separately below. This would be equivalent to around **£3.95 billion in 2015** if adjusted for inflation.

Overweight and obesity is a complex disease affected by the interaction between genetics and lifestyle (dietary habits and levels of physical activity). Studies have tried to disentangle the relative contributions of genetics and environment as factors behind the development of obesity, but it is difficult to estimate with any accuracy the specific roles of each. Estimates vary from between 30-90% of BMI variance associated with genetics and

Highly processed foods containing sugar and modified fats are a major cause of obesity (Photo: Steve Vidler / Alamy)

AGRICULTURE AND OBESITY

The relationship between agriculture and obesity is complex and distorted by the rise of supermarkets, the increased consumption and high levels of advertising related to highly processed foods and arguably to changes in dietary advice, such as the recommendation to reduce consumption of animal fats and increase consumption of carbohydrates[149] and processed vegetable oils.[150]

However, it is clear that one way or another we consume the foods that are produced by farmers, and the increasing dominance of a narrow range of food crops both facilitates and reflects current consumption trends. In Wales, for example, twice as much land was producing vegetables forty years ago compared with today.[151]

Obesity increases the risks of serious health problems, including heart disease, stroke and Type-2 diabetes, all of which lead to increased health care costs and place a greater burden on the health care system.

30-70% with environmental factors (diet and lifestyle).[152] Given the variation in estimates, we are conservatively attributing only 30% of the costs associated with obesity to dietary factors.

Taking 30% of the estimated cost of £3.95 billion in 2015 gives us a figure of £1.19 billion for the diet-related component of obesity.

A 2007 paper on the economic costs of obesity included estimates for both the direct healthcare costs to the NHS in England (up to £1.1bn in 2002) as well as the cost of lost earnings (lost potential national output) directly attributable to obesity (up to £2.6bn in 2002).[153] Direct healthcare costs made up only 30% of the total cost, with 70% coming from lost earnings. The authors also indicate that welfare costs (due to incapacity to work as well as unemployment) may be as high as £6bn and lost earnings as much as £10bn or more. They also suggest that there is considerable evidence that employers discriminate against the obese – which would add yet more to total lost earnings.


High blood pressure affects a quarter of all adults in England (Photo: Sheila Fitzgerald / Alamy)

Taking the figure of £1.19 billion for obesity costs in 2015, and adding the remaining share for lost earnings (using the 30% to 70% ratio) gives us a figure of **£3.86 billion** for direct costs and lost earnings related to obesity. This figure doesn't include costs related to overweight, and it doesn't include additional costs to society related to care in the community and further welfare costs.

Background

Obesity is a rising epidemic. Worldwide, rates of obesity have more than doubled since 1980. Today, more than 1.9 billion adults are overweight – equivalent to over a quarter of the world's population – and over 600 million of these are obese.[154] In the United States more than one third of the adult population and 17% of youths are obese.[155] The picture is almost as stark in England, where 26% of men and 16% of women were obese in 2013. In total, 62% of adults and almost one third of children aged between 2 and 15 years were either overweight or obese in England in 2014.[156]

Zoë Harcombe argues that before the 1970s only 2-3% of the UK population were obese, compared to approximately 25% today.[157] As such, many authors have argued that changes in the diet during the 1980s have played a major part in the rise of obesity.[158]

Hypertension

Costs

According to Public Health England, diseases resulting from high blood pressure are estimated to cost the NHS over £2 billion per year.[159] Given that about half of hypertension can be attributed to unhealthy diets (high salt consumption and low dietary potassium – related to low fruit and vegetable consumption),[160] this would mean roughly **£1 billion of the total cost to the NHS in England** relates to food consumption. This figure would be slightly higher if it included Scotland (where hypertension cost the NHS £38 million in

2007-2008[161]), Wales and Northern Ireland but no recent data was available for these countries.

Background

Hypertension is a public health epidemic, estimated to cause almost 7.5 million deaths per year globally, about 12.8% of the total of all deaths.[162] In England, hypertension affects 1 in 4 adults and is considered one of the biggest risk factors for premature death and disability.

Dementia

Research published by the Alzheimer's Society in 2014 predicted there would be 850,000 people living with dementia in the UK by 2015, and that this would cost the UK £26 billion a year, at an average annual cost of £32,242 per patient.[163] Of this the NHS picks up £4.3 billion, £10.3 billion goes on social care (funded by dementia sufferers, their families, central and local government) and £11.6 billion is contributed by unpaid carers. Other costs relate to police time looking for missing dementia sufferers and research.[164]

The King's Fund predicts the costs will increase to £34.8 billion by 2026. These estimates take into account the medical and social care associated with the illness, but not other costs such as loss of life years or loss to the economy due to inability to work.

A number of different dietary factors have been suggested as contributory causes, but none of these is yet conclusively proven.

There is evidence that pesticides are linked to neurodegenerative diseases, including Parkinson's disease and Alzheimer's, as a result of oxidative stress, mitochondrial dysfunction, and neuronal cell loss.[165]

A few studies have indicated a possible link between dementia and raised glucose levels, which suggests that diets high in sugar may increase dementia risks.[166]

Several studies have investigated the benefits of omega-3 fatty acids in treating and preventing dementia. One review concluded that overall there is little convincing evidence of a benefit from omega-3 supplements on dementia suffers.[167] A possible explanation for this is that many omega-3 supplements contain only alpha-linolenic acid, and only a small proportion of this breaks down into the more valuable long chain omega-3 fatty acids. Natural sources, such as oily fish are to be preferred and at least one study has shown that people on diets low in omega-3 are at greater risk of developing dementia.[168]

This raises questions about the extent to which changing production methods may be contributing to the problem. There is much less omega-3 in grain-fed compared with grass-fed beef and omega-3 levels in farmed fish have fallen sharply (see Chapter 5).

Although the evidence strongly points to diet as a contributing factor in the development of dementia, there are currently no reliable estimates of what proportion relates to food compared with other risk factors. As such, we are not able to include any costs for dementia at the present time.

It should be noted, that some of the costs allocated to malnutrition in this report may be due to dementia, since there is evidence that those developing dementia are less capable of maintaining healthy diets than they would otherwise be.

Poor diets are a factor in the rise of dementia, but also a consequence of it (Photo: Brett Gardner / Alamy)

5. FOOD PRODUCTION-RELATED HEALTH COSTS

> *“Often we find that because animals are kept in a group if one gets an illness they all go down, so you will often end up treating the whole group, which is sensible but means a lot of drugs are used. But in antibiotics we need to reduce the use for all animals. The bugs that infect humans are very similar to the bugs which infect animals, sometimes they are the same, so we are using the same drugs to fight them.”*
>
> **Professor Nigel Gibbens, UK Chief Veterinary Officer**

By dealing with food production-related health costs and food consumption-related health costs separately we are attempting to distinguish between those costs which principally relate to the way in which food is produced and those which principally relate to the diets which consumers adopt.

Even here, though, the situation is far from straightforward. On the one hand food poisoning is also associated with poor standards of food preparation, as well as the way the foods are produced.[j]

On the other hand, although we have included all the diet-related disease costs in the preceding chapter, emerging evidence suggests it is unlikely that any of these are exclusively related to dietary choices. The 'Chemical Obesogen Theory', argues that exposure to certain pesticides and food additives etc. is a factor in the continuing rise of obesity.[169] Increasingly, research is also establishing the importance of a healthy gut microbiome in both preventing and treating disease. Research in Taiwan has found that exposure to some pesticides is a factor in increased risk of DNA damage in a subset of the population.[170] At the same time an 8% compared with 4% level of long chain omega-3 fatty acids in red blood cells as, a percentage of total fatty acids, has been associated with a 90% reduction in the risk of sudden cardiac death,[171] and a reduced risk of breast cancer.[172] Yet, according to Professor Douglas Tocher, from Stirling University, levels of omega-3 have halved in the last five years.[173] The trend since the 1950s of feeding high levels of grain to a significant proportion of cattle has also resulted in a 6-7 fold reduction in the amount of omega-3 fatty acids in beef from some cattle reared in the UK.[174]

Antibiotic resistance

Costs

A UK study on the economic burden of antimicrobial resistance indicated that the cost to society could be as high as £10 billion per year.[175] As yet, there is no reliable breakdown of the extent of the problem originating from farm use of antimicrobials and that originating from use in human medicine. Applying data from the Centers for Disease Control and Prevention (CDC) in the US which indicates that 22% of AMR is food-related, and applying it to the UK would mean that, very roughly, food-related AMR may have cost as much as £2.2 billion in 2012, or roughly **£2.34 billion in 2015.**

A study by RAND Europe estimated that by 2050 the world economy could be up to 3.1% smaller, depending on the future rates of antimicrobial resistance. Since these GDP losses are annual and thus compound over time, they calculate that this would result in cumulative losses that range between $2.1 trillion and $124.5 trillion.[176]

Background

Antibiotic resistance is becoming an increasingly serious threat to human health through the progressive loss of effective therapeutic treatment options for many diseases and infections. While a large part of this problem stems from over-use of antibiotics in medical care, another part comes from their use in agriculture,[177] much of which is for commercial rather than therapeutic purposes. Opinion varies widely on the split between these two major

j We have not allowed for this since we have no way of apportioning these costs and the primary source of food poisoning bacteria is food animals and the farming systems from which they originate.

Most intensive pig and poultry systems are heavily dependent on the use of antibiotics in feed or water (Photo: Rob Cousins / Alamy)

sources, but according to the CDC in the US, 22% of antibiotic-resistant illness in humans is linked to food.[178]

Livestock are routinely administered with antibiotics, particularly when kept in intensive conditions. In the UK, around 45% of antibiotics are used for animals,[179] and in the EU as a whole the figure is around 66%.[180] Many of these are not used to treat sick animals but are included in feed and water used for preventative purposes. Livestock are increasingly developing drug-resistant bacteria in their intestines and sometimes on their skin that can remain on meat and pass to humans. Additionally, animal manures or contaminated water containing drug-resistant bacteria can be used on crops.

Farm antibiotic use is the principal cause of resistance in campylobacter and salmonella bacteria. The rise in resistance in *E. coli*[181] and enterococci is also partly related to farm use.[182] Over the last decade a major new development has been the emergence and spread of MRSA strains colonising farm animals which can pass to and infect humans.[183]

Food poisoning

Costs

In 2008 this cost £1.5 billion, equivalent to around **£1.8 billion in 2015,**[184] due to hospital treatment and deaths. Campylobacter alone is considered to cost the UK economy about £900 million.[185]

Background

Food poisoning is caused by ingesting bacteria, principally salmonella, camplyobacter, *E. coli* and listeria, or viruses, such as norovirus, generally via contaminated food. In the UK, it is estimated that each year around a million people suffer a foodborne illness.[186]

Chicken is one of the most common sources of food poisoning. Intensification of livestock production facilitates disease emergence and transmission by increasing population size and density.[187]

Campylobacter is the most common cause of food poisoning in the UK. About four in five cases of campylobacter poisoning in the UK come from contaminated poultry. Less common sources of contamination are red meat, unpasteurised milk and untreated water. A UK survey carried out between 2007 and 2008 found that campylobacter was present in 65% of chicken on sale.[188] Figures from the UK Food Standards Agency for campylobacter indicate that it is responsible for more than 280,000 cases of food poisoning each year and an estimated 100 deaths.

It is of note that campylobacter only emerged as a cause of food poisoning in the early 1970s, almost twenty years after the intensification of

Chicken is the primary source of food poisoning bacteria in the UK and a source of antibiotic resistance (Photo: Gary Naylor)

pig and poultry production was made possible by the routine use of antibiotics in feed in the UK in 1953.

Incidence of salmonella has declined since the vaccination of poultry in the late 1990s, and there are now around 10,000 reported cases in the UK.[189] *E. coli* food poisoning occurs less frequently but causes the most serious health problems. There are approximately 1,000 cases per year across the UK.[190]

Organophosphate pesticides

Costs

The health impacts and costs related to pesticide exposure in the UK are unknown. Within the US, health costs related to pesticides have been estimated to be around $1 billion due to pesticide poisoning, equating to $5.98 per hectare or $2.26 per kg of pesticide.[191] However, these are likely to be underestimates, due to differing risks per product, poor understanding of chronic effects and weak monitoring systems. A major recent study calculated that exposure to Endocrine Disrupting Chemicals (EDCs) across the European Union costs €157 billion a year (within a range of €81.3 billion to €268 billion), or at least 1.23% of GDP in health care expenses and lost earning potential.[192] The financial burden to the UK alone was estimated at around €24.7 billion.[193]

In terms of agriculture-related EDCs, exposure and especially pre-natal exposure to organophosphates (which are active in about half of all pesticides[194]) can cause neurobehavioural disorders related to loss of IQ and intellectual disability. This is estimated to cost approximately £128 billion annually across the EU.[195] In 2016, the proportion of UK pesticide sales within the EU-28 total was estimated at 4.6%[196], therefore taking 4.6% of £128 billion gives a reasonable cost estimate of approximately **£6.4 billion** per year.

Background

We come into contact with pesticides through direct exposure, their release into the environment, and as residues in food and water. Farm workers who handle and apply pesticides regularly are at the greatest risk of harm. According to the WHO, up to 5 million cases of pesticide poisoning occur every year, with 20,000 people dying as a result.[197]

A European Food Safety Authority found that almost 5% of fruit and vegetable samples tested (and 3% of food samples as a whole) contained one or more pesticide residues above the

Pre-natal exposure to organophosphates contained in many pesticides, has been linked to poor brain development in children (Photo: Gary Naylor)

European legal limits. In addition, a quarter of all surface water reservoirs used for drinking water in the UK are at risk of exceeding the pesticide limits set out in the EU's Water Frameworks Directive.[198]

A review for the WHO by the International Agency for Research on Cancer has concluded that glyphosate, the most widely used herbicide, is 'probably carcinogenic to humans',[199] although two EU committees have not come to the same conclusion.[200] The authors are unable to make a more unequivocal assessment because there are only a limited number of relevant studies in humans. The same study also concluded that two organophosphate insecticides, malathion and diazinon are also probably carcinogenic, while the organophosphate insecticides tetrachlorvinphos and parathion are possibly carcinogenic.

Scientists in New Zealand have also established that glyphosate, registered long ago by Monsanto as an antibiotic, and two other widely used herbicides, 2,4-D and dicamba, induce resistance to certain antibiotics in *E. coli* and *Salmonella typhimurium*.[201]

Amongst EDC pesticides, cost estimates have so far only been undertaken for organophosphates, but the health costs associated with pesticides such as glyphosate are potentially huge, though currently impossible to estimate.

EDCs are mostly man-made chemicals found in a range of products including synthetic hormones, many pesticides and some metals, food packaging materials and personal care products. They interfere with the hormone system and can cause developmental, reproductive, neurological, and immune system problems in humans, farm animals and wildlife. Reduced fertility, cancer, birth defects and learning difficulties have all been associated with these chemicals. They can be especially damaging to a developing foetus.

There is particular concern about EDCs which become stored in body fats because these cannot readily be metabolised and therefore tend to bioaccumulate, both in individuals and progressively up the food chain. Many such pesticides, for example DDT and other organochlorines have now been banned in the UK, but due to their persistence they can still be found in the environment. As a result, the consumption of oily fish (seen as healthy due to their high concentrations of long chain omega-3 fatty acids) or other foods that contain residues of manmade chemicals can also be a source of EDCs.[202]

Colon cancer from nitrate in drinking water

Costs

The financial cost (monetary value of loss of healthy life years) of nitrate-related colon cancer has been estimated at €1 billion per year across 11 EU countries, roughly equivalent to €43 million (2010) or **£43.5 million for the UK in 2015.**[203] However, this calculation was based on data from the early 1990s. Nitrate in drinking water in the UK have been kept below the EU safety limit of 50 ppm for some time and it is unclear whether current levels of nitrate in drinking water pose a health risk. The EU advisory limit, however, is 25 ppm and in some parts of the country water contains 50 ppm of nitrate or more.[204] While we are not including this cost, it is of note that UK consumers spend £2.4 billion annually buying 3.2 billion litres of bottled water.[205] There are multiple reasons for this, but concern about the potential impact on their health from high nitrate levels is likely to be one factor, most bottled water having very low levels of nitrate.

Background

Around 16,000 people die from colon (bowel) cancer in the UK and over 40,000 new cases are diagnosed every year.[206] It has been estimated that over 70% of colon cancer risk is preventable through changes to diet and lifestyle, while the remaining 30% is associated with age, genetics, and exposure to risk factors.[207]

Studies have linked high nitrate levels in water to colon cancer,[208] and public drinking water and the use of private wells has also been associated with increased the risk of ovarian cancer among postmenopausal women in the US.[209] The European Nitrogen Assessment included research suggesting that high nitrate levels in EU drinking water are associated with at least 3% of bowel cancer cases.[210]

High nitrate levels in drinking water also reportedly lead to an increased risk of brain tumours, leukaemia, and nasopharyngeal carcinoma. A few studies have reported other health effects that are possibly associated with nitrate exposure in children, including increased incidence of childhood diabetes, recurrent diarrhoea, and recurrent respiratory tract infections. Other reported effects of chronic exposure in adults include frequent urination and spleen haemorrhaging. Acute high dose ingestion exposure to nitrate can cause abdominal pain, muscle weakness, blood in stools and urine, fainting, and death.[211]

Additionally, nitrate intake from food is four times the intake via drinking water.[212] This also has potentially carcinogenic effects. Despite the slightly higher incidence of colorectal cancers found in people who eat above average amounts of processed meat, there is little consensus in the literature on whether the addition of either nitrate or nitrite to food as a preservative in products like bacon, is a cause of cancer. Nitrate itself is relatively non-toxic but it breaks down into nitrite and a number of other potentially harmful compounds in the body. According to a review by the European Food Safety Authority (EFSA) the typical intake of nitrate from drinking water and cured meats combined is 35-44 mg/person per day, well below the Acceptable Daily Intake for a 60 kg adult of 222 mg per day.[213]

However, most food also contains nitrate and the levels can vary greatly according to method of production. Leafy vegetables such as lettuce and spinach (recommended for other health reasons) contain particularly high levels of nitrate. In general, vegetables grown using compost have lower levels of nitrate than those grown with nitrogen fertiliser.[214]

In contrast to leafy vegetables, fruit is relatively low in nitrate and the EFSA review states that because most people get a high proportion of their recommended 400 g of fruit and vegetables a day from fruit, most people will be well within the ADI. However, the review also notes that for the 2.5% of the population in some EU countries that eat only leafy vegetables and large amounts of them, intakes could exceed twice the ADI, depending on the way the crop was grown. As such the impact on public health from the levels of nitrate in food is still largely unknown and a cost cannot therefore be estimated currently. However, the incidence of many of the health conditions putatively linked to high nitrate intake have increased in recent decades in tandem with nitrogen fertiliser use.

People in the UK consume 3.2 billion litres of bottled water every year, at a cost of £2.4 billion, partly due to concern about nitrate and pesticide levels in tap water (Photo: CBW / Alamy)

6. FARM SUPPORT PAYMENTS & REGULATION

> *"There are very good reasons why we should provide support for agriculture. Seventy per cent of our land is farmed – beautiful landscape has not happened by accident but has been actively managed…Agriculture is an industry more susceptible to outside shocks and unpredictable events – whether it's the weather or disease. So financial assistance and mechanisms which can smooth out the vicissitudes farmers face make sense."*
>
> **Michael Gove, Secretary of State for Environment, Food and Rural Affairs**

Costs

Between 2014-15, Defra had access to £6.3 billion in funding: £2.6 billion of this (41%) came directly from the Exchequer. Almost half of all the funding (49%) to run Defra came from the EU, most of it through the Common Agricultural Policy and Rural Development Programme funding worth a total of £3.1 billion. Additional income comes from fees, levies and licences worth a total of £421 million.

Clearly not everything Defra does relates directly to food and farming, but the vast majority of what it spends money on does. The executive agencies, which cost over £3 billion each year, work directly in food and farming. Over £1.4 billion spent on 'Water and Flood Risk Management' also relates directly to land use and therefore agriculture and the way we manage land to produce food.

In addition, there is the added cost associated with funding from the Biotechnology and Biological Sciences Research Council which goes towards food and farming research, including £35.5 million for Rothamsted Research and £20.7 million for the Institute of Food Research.[215]

We've been unable to establish the contribution of taxpayers towards agricultural education and research in universities and colleges, which is another way in which consumers support agriculture without fully realising it, and a resource which could be redirected more specifically to sustainable food production.

The true cost to the taxpayer of financing Defra's ongoing work subsidising and supporting food, farming and the environment in the current economy is around £6.3 billion per year. Adding the BBSRC figures to this give us a total of around **£6.4 billion per year,** equivalent to just under £100 per person per year.

Table 2: Operating costs for the Department for Environment, Food & Rural Affairs (2014-2015)[216]

Programme	Total spend (£000)
Animal and Plant Health Scanning and Trade Policy Directorate	62,401
Animal Health and Welfare: Disease Control Directorate	157,733
Marine and Fisheries Operations	69,772
Climate, Waste and Atmosphere	425,914
Rural Development	127,351
Sustainable Communities and Crops	614,323
Sustainable Land Management and Livestock Farming	284,381
Water and Flood Risk Management	1,410,902
Executive Agencies	3,148,117
Total operating cost	**6,300,894**

Background

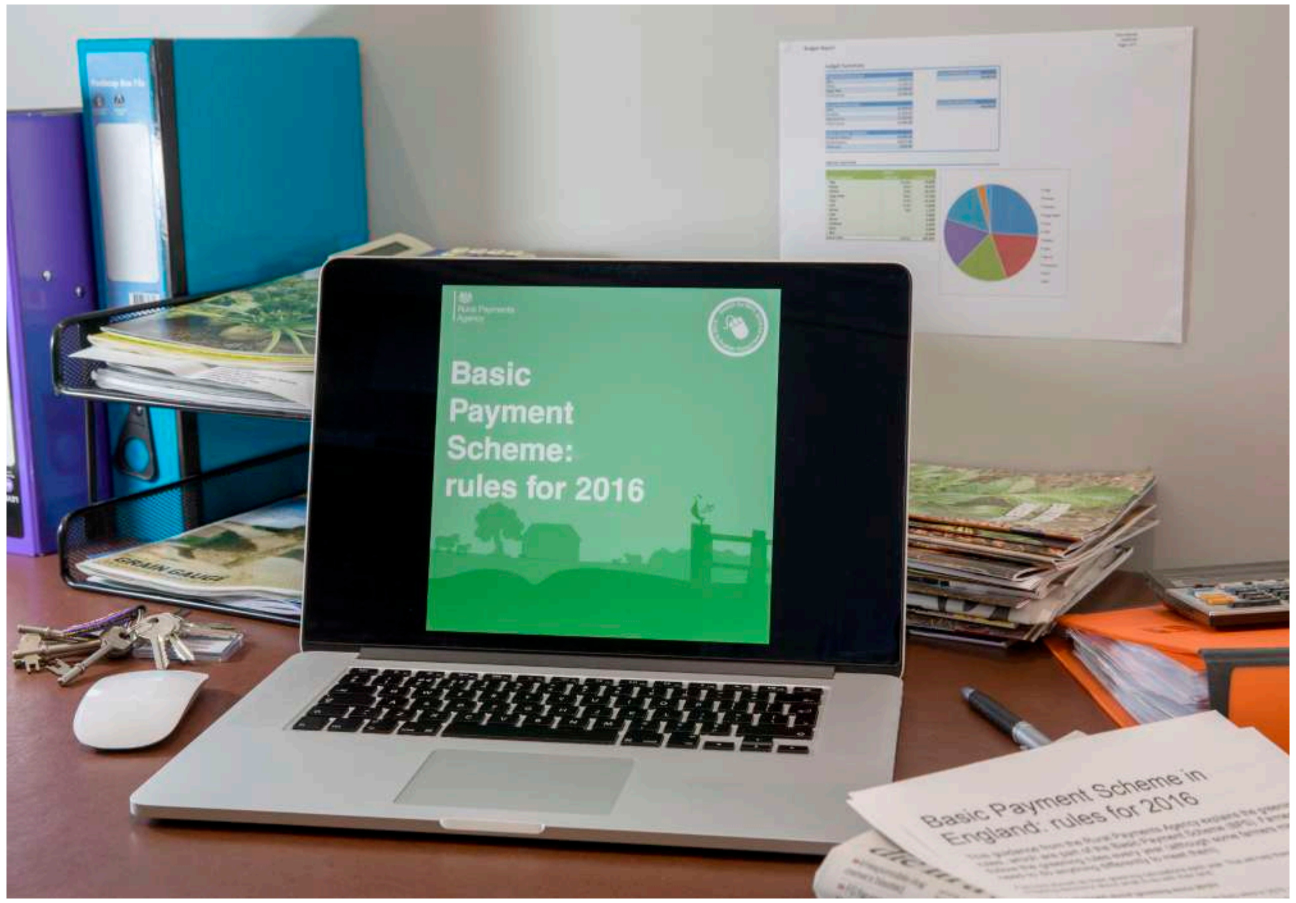
The EU Common Agricultural Policy (CAP) is the main source of finance for agricultural subsidies. It is financed through two different funds: The European Agricultural Guarantee Fund (EAGF), which mainly supports farmers through direct payments/subsidies, as well as implementing measures to regulate and support agricultural markets (Pillar 1); and the European Agricultural Fund for Rural Development (EAFRD), which supports rural development programmes by offering grants and financial contributions to projects across rural parts of the EU (Pillar 2).

Approximately 38% of the EU budget, equivalent to €408.31 billion for the period 2014-2020, is spent on these two funds to support agriculture and rural development through Pillar 1 and Pillar 2 payments. Through a combination of grants and subsidies, the CAP directly supports more than 113 million people living on 170 million hectares of agricultural land.[217]

However, only 23% of financial resources are directed to Rural Development Programmes (RDPs, 2nd pillar of the CAP), which support farmers to take up schemes which produce positive environmental externalities. The rest of the budget (77%) provides support to farmers' income, through area based subsidy payments.

In recent years, payments above €150,000 per farm have been reduced by 5%, and farmers also have to abide by certain greening regulations. Farmers and market gardeners with less than 5 hectares receive no payments. Overall, this system encourages intensive farming and increased holding size.

Whatever replaces this post-Brexit, it is arguable that taxpayers' money should be used in the future to achieve both food and environmental security.



Completing complex forms online is stressful for farmers, but support payments only account for 2.5% of the hidden costs of the UK food system (Photo: Gary Naylor)

7. FOOD IMPORTS

"For a country blessed with a fine climate and soils for producing good fruits and vegetables, the reality of vast importation of produce which could be grown here suggests that UK policy is tacitly a kind of 'soft' food imperialism – using others' land and labour rather than one's own. What horticulture there is in the UK relies heavily on imported labour."

'Horticulture in the UK: potential for meeting dietary guideline demands' (2006)
Victoria Schoen and Tim Lang

Estimating the hidden cost of food imports

Costs

The Office of National Statistics publishes data on the total value of UK trade in food and livestock feed (both imports and exports). In 2015, the combined value of food, livestock feed and soft drink exports was £10.6 billion, while imported food, livestock feed and soft drinks were valued at £26.4 billion, creating a trade gap of £15.8 billion, with slightly more livestock feed imported than exported (a trade gap of £93 million).[218]

While the externalities associated with different food products will vary significantly and some externalities in exporting countries are likely to be higher than in the UK, others may be lower. As such, all we can do for now to obtain a crude estimate, is to express the net £15.8 billion value of imports as a percentage of the externalities associated with food purchased in the UK.

In 2015, total consumer expenditure on food, non-alcoholic drinks and the 'food cost share' of catering was £120.14 billion.[219]

A third of all soya imports in the UK are fed to farm animals (Photo: Jim Gobson / Alamy)

This report finds that the cost of the negative externalities associated with food production in the UK (natural capital degradation, biodiversity loss, food production-related health costs, and subsidies and regulation) is approximately £68.12 billion annually (see Executive Summary). In other words, the £120.14 billion spent on food was associated with production externalities of £68.12 billion, or £0.57 for every £1 spent on food. On this basis, we can very roughly estimate that the production externalities associated with imported food could be in the region £9.01 billion (£15.8 billion x £0.57).

If we add the hidden cost of importing palm oil (see section 'Hidden cost of importing palm oil' directly below) of roughly £287 million per year, this gives us an estimated total of **£9.29 billion** for the hidden cost of food imports in 2015.

Background

The UK produces just over half (52%) of the food it consumes – in terms of farmgate value before processing. Another 29% comes from the EU and the rest from Africa, Asia, North and South America and other countries.[220] In terms of the value of farmgate sales, therefore, 48% of the food consumed in the UK comes from outside the country. In terms of matching production to consumption, 61% of the food we eat is home produced and 39% imported.[221]

When it comes to specific crops or food categories, there is considerable variation. For example, although the UK imports significant quantities of high quality bread-making wheat, it is essentially self-sufficient in cereals (exporting and importing similar amounts) and oilseed rape, but only partially self-sufficient in meat and eggs: sheep meat (92%), beef (74.8%), poultry (73.3%), pork (55.3%),[222] and eggs (85%).[223] It also produces only 14% of the fruit, 55% of the fresh vegetables, and 77% of potatoes it consumes[224] while also importing a very high proportion of the protein fed to livestock.[225]

While the calculation above is our best estimate, based on the limited data, it is, however, likely to be an underestimate for two key reasons:

1. Soil degradation can be much more rapid and environmental pollution more extreme in cleared rainforests and other virgin lands, from which much of our imported food now comes.
2. The UK now imports a very high proportion of the fruit and vegetables it consumes. Much of this comes from drought prone regions, yet it contains large amounts of virtual water, the use of which creates far bigger negative impacts in drought-stricken regions and dryland than would be the case for similar quantities of water used for crop production in the UK.

Our estimate also does not include the externalities associated with the international transporting of food by sea and air, which include sulphur and other causes of air pollution from the heavy fuel oil used by most ships and the GHG emissions associated with fossil fuel use and refrigerants to keep many food commodities chilled or frozen which are not accounted for in the inventories of either exporting or importing countries.[226] International shipping is responsible for 866 million tonnes of CO_2 equivalent emissions (2.4% of the global total),[227] but there is no readily available data on how much of this relates to food.

It is also likely that because a significant proportion of UK food and drink imports come from former rainforest regions in the form of vegetable oils, high protein livestock feed and chickens, that many of the production-related externalities will be higher than in the UK, as the following example relating to palm oil illustrates.

Hidden cost of importing palm oil

Costs

In a recent Economics of Ecosystems and Biodiversity for Agriculture and Food (TEEBAgriFood) report on the hidden costs of palm oil,[228] the authors estimate that palm oil production in the main 11 producing countries has a natural capital cost of $43 billion per year, compared to the commodity's value of $50 billion – crude palm oil makes up $37.5 billion and palm kernel oil another $5 billion. Given that the UK imports about 0.7% of global production,[229] this is roughly equivalent to £260 million per year in natural capital costs. In terms of human capital cost, underpayment and occupational health impacts on oil palm plantations account for $592 per full time employee, equivalent to $35 per tonne of palm oil and $53 per tonne of kernel oil.[230] In 2011, the World Bank estimated that the palm oil industry employed over 6 million people[231] - using this figure would result in a human capital cost of £3.552 billion. However, this figure is likely a huge underestimate because of the continuing growth of the industry, and as it does not account for casual, subcontracted, temporary and part-time workers, which on some plantations make up 50% of staff[232]. However, for now UK human capital costs would account for just under £26.5 million which, when added to the natural capital cost of £260 million, gives us a conservative total estimate of **£286.5 million**.

Background

Palm oil has become the most widely consumed vegetable oil with 33% of the total share of vegetable oils consumed globally.[233] In 2014, the UK imported approximately 415,000 tonnes of palm oil and 26,000 tonnes of palm kernel oil (excluding derivatives),[234] accounting for more than three-quarters of all animal and vegetable oil imports to the country that year.[235]

The problems associated with palm oil production have been widely documented and include deforestation and habitat destruction,[236] biodiversity loss,[237] climate change, air and water pollution,[238] soil erosion, and the social, labour and human rights impacts of land grabs.[239]

Destruction of tropical rainforest to grow palm oil has a wide range of serious impacts (Photo: Rainforest Action Network / Flickr)

8. SOCIAL, CULTURAL AND ETHICAL ISSUES

> *"There is a silent crisis in the farming sector. Smaller farms struggle to compete in the current market and, if the current trends continue, they could all but disappear from the English countryside by the middle of the century"*
>
> **'Uncertain Harvest: Does the Loss of Farms Matter?' (2017)**
> **Graeme Willis, Campaign to Protect Rural England**

> *"Farmers are more prone to suicide than almost any other professional group. They see themselves as failures, particularly if they've inherited their land. I worry about farmers on small units.... who have only known farming their whole lives and tend to be more isolated."*
>
> **Meurig Raymond, President of the National Farmers' Union, 2015**

Most people will readily see the logic of attaching costs to things that directly incur expenses which governments or insurers have to pay out, but which are ultimately paid for by citizens in other ways, such as through taxes or insurance premiums. An obvious example of this would be where extensive or flash flooding is linked to soil erosion due to tree felling, or the growing of forage maize for high-yielding dairy cows.[240]

At first look, however, it might seem inappropriate or even insensitive to put financial values on social and cultural issues such as the value of rare wild flowers or a beautiful landscape. Closer examination, though, reveals that these and many similar issues which impact on human wellbeing, do actually have financial values, which can be positive or negative depending on the example under consideration.

In the 2007 Defra publication, *An Introductory Guide to Valuing Ecosystems*,[241] this is recognised, and while it may never be possible to put absolute values on such things, economists have developed a wide range of approaches which allow informed estimates to be made. In the case of a lovely view, for example, they use 'hedonistic pricing' – this assumes that the value of the view will be reflected in increased property prices in the area.

In general, such methods have not yet been applied to social, cultural and ethical issues associated with food systems, except those related to landscapes, but with the political will, there is no reason why research should not be extended in this way.

Poor farm animal welfare is another complex social and cultural issue. The most obvious negative consequences of intensive livestock production including pollution, food poisoning and antimicrobial resistance, are already included in this report under those headings. But might it be possible to demonstrate other more intangible costs for society associated with our dependence on animals forced to live boring, unfulfilled and sometimes painful lives?

Below we list a few of the social, cultural and ethical issues which have links with food and farming that have, or are likely to have, hidden costs for society and/or individuals.

- Animal welfare
- Mental health
- The declining farmgate price of food
- Employment and labour conditions
- Cultural impacts

Animal welfare

The cost of the negative externalities related to industrial livestock production across the EU have been assessed by Compassion in World Farming to be around €168.69 billion.[242] Most of these costs relate to issues such as environmental pollution, GHG emissions, antibiotic resistance, soil degradation and food poisoning, which have all been included in this report under the sections to which they relate. The total figure also includes an animal welfare cost related to pork production in the Netherlands.[243] In this study, the authors compared prices of conventional pork and organic (higher welfare pork) to determine what the willingness-to-pay for pig welfare might be. CIWF uses this range to estimate that the animal welfare costs for the EU pig sector are around €19 billion per year.

But a wider question remains about whether there are broader subliminal costs on society associated with intensive livestock production, although these may be difficult to calculate. For example, some research has shown that property prices may be affected by the location of intensive livestock production units such as confined animal feeding operations (CAFOs). One such study found that the loss of land value within 3 miles of a CAFO in Missouri, USA, was approximately $2.68 million, or $112 per acre due to the negative impacts of air pollution, despite some positive impacts due to job creation.

In addition to this, there is some evidence for a decline in the consumption of some important micronutrients and an increase in less beneficial nutrients due to changes in food production and processing methods. For example, it is increasingly known that grass-fed beef contains a healthier fatty acid profile as well as antioxidant content than grain-fed beef (which is associated with production systems with lower welfare).[244]

Confined livestock have unfulfilling and often painful lives. Does this impact on us, as well as them? (Photo: Gary Naylor)

There are also human mental health benefits, as well as educational, of interacting with animals, whether as pets or in a farm setting.[245] There are likely therefore to be some negative impacts on human wellbeing from production systems with poor animal welfare, although detailed evidence on this – particularly of the kind that has been monetised – is currently lacking.

Mental health

Trying to assess the extent to which current food systems are associated with mental ill-health is a complex task. There has been significant coverage of the extent to which falling farm gate prices, increased paperwork and the impacts of diseases, such as bovine tuberculosis and foot and mouth, increase levels of depression and suicide in farmers who often face mounting financial pressures and spend much of their working life isolated from others. But there are two further dimensions to this issue which to date have received little consideration.

First, there are the costs associated with the increasing number of former farmers and farm workers who lack the skills to find other meaningful work and/or find it difficult to adapt to urban life. Second, there is the extent to which farm size and land prices have increased, due in part to the way in which farm support payments have been structured, making it increasingly difficult for anyone outside the industry to get access to land in order to enjoy the therapeutic benefits of growing their own food or working with farm animals in unstressed environments.

The annual cost of mental health in the UK has variously estimated at £70 billion in 2014 by the Organisation of Economic Cooperation and Development[246] and £100 billion in 2014/15 by the NHS Confederation. In 2014/15, 1.8 billion people used mental health services and 103,840 of these were admitted to hospital as a result.[247] A proportion of this total cost – we do not have the data to say how much – will be associated with failings in the current food system.

In 2016 the UK Government published a report from the charity MIND and Essex University.[248] This found that: 'The mental health benefits for social and therapeutic horticulture, environmental conservation interventions and care farming were similar and include:

- Psychological restoration and increased general mental wellbeing

- Reduction in depression, anxiety and stress related symptoms
- Improvement in dementia-related symptoms
- Improved self-esteem, confidence and mood
- Increased attentional capacity and cognition
- Improved happiness, satisfaction and quality of life
- Sense of peace, calm or relaxation
- Feelings of safety and security
- Increased social contact, inclusion and sense of belonging
- Increase in work skills, meaningful activity and personal achievement

Farmer suicides

The Huffington Post reported in 2014 that on average one farmer a week commits suicide in the UK,[249] among the highest of any occupation. This is the most acute evidence of the problem of mental ill-health amongst farmers and their families. An article in Countryfile Magazine in 2015, published to coincide with the launch of a campaign to raise awareness about mental health issues among farmers, explained the background to the problem: 'Farming is a high-pressure, 24/7 occupation with lack of days off compared to almost all other professions, and farmers face increasingly difficult market pressures, the risk of disease infecting livestock and the potential of flooding to completely decimate livelihoods'.[250]

There has been little if any analysis of the link between the exodus of small and medium-sized farmers in recent decades and the incidence of depression and suicide. Between 1995 and 2014 the number of dairy farms in the UK declined from 35,741 to just 13,815, almost 22,000 farmers and their families in total.[251]

Most of these relate to dairy farmers who were no longer able to make a living due to growing supermarket dominance of the industry, the disbandment of the Milk Marketing Board, the ending of a fair national price for milk paid to all farmers regardless of their location, and the removal of milk quotas - all changes which were politically driven, at least in part. There have also been similar declines in the number of beef cattle producers. In all these cases, the farmers and their families go through years of trying to survive by borrowing more money, trying to save costs by cutting down on labour and working longer hours themselves.

The US National Institutes of Health has also linked pesticides with mental ill-health, saying that farmers can breathe in and absorb pesticides though the skin while applying them to crops and that these can have neurological effects.[252]

In theory, current safety regulations on the handling and use of pesticides should reduce or prevent such risks, but it is widely recognised within the industry that during hot weather farmers applying pesticides to livestock, especially sheep, are prone to discarding protective clothing.

In addition, there are the physical and mental health impacts on workers having to perform small repetitive tasks in the food processing sector. There are also the impacts on humans of working in continuous chain slaughterhouses – with the violent abuse of animals that can result from the dehumanising effect of working in these settings, where each worker performs the same task over and over again. This is in contrast to the situation in the declining number of smaller abattoirs where workers are involved in all aspects of slaughter, are able to see themselves as craftsmen and can take pride in their job.[253]

The price of food

Over the last half century, food prices have risen slower than incomes and house prices,[254] thereby appearing to decline overall, although food prices in real terms today have hardly changed since the mid-1990s (bar a slight rise between 2009 and 2014 followed by a dip).

The price of food has been driven down by competition between supermarkets, but farmers and the environment pay for this (Photo: Alex Segre / Alamy)


Seasonal labour is increasingly replacing regular farm jobs (Photo: Gary Naylor)

Despite this, food expenditure as a proportion of average income is the lowest it has ever been, at around 8.3% compared to 34% in 1947,[255] lower than every other country in Europe.[256]

This is generally seen as a good thing and one of the developments that have increased the standard of living. Food has appeared to get cheaper due to: the removal of trade barriers, the removal of quotas within the EU, and increased production efficiency. Production has become more efficient due to higher yields, the greatly reduced labour force, increased mechanisation and specialisation and the importation of agricultural inputs, such as nitrogen fertiliser, from countries where state subsidies on energy generation and sometimes lower environmental standards allow products to be produced more cheaply than in the UK.

However, the slow rise in food prices compared to other household expenditure has had a huge range of negative impacts on farmers, on farms, on rural communities, and on consumers themselves in ways that are not immediately obvious. It has also contributed to the UK's balance of trade deficit and the demise of a high proportion of market gardeners and small farmers who have been unable to compete.[257]

This decline in the number of smaller farmers has also meant that there are reduced opportunities for non-farmers to obtain therapeutic benefits of working on the land and with farm animals. A first sign that this association is coming to be recognised at government levels comes in the form of a recent review of 'nature-based interventions for mental health care' by Essex University and Mind, commissioned by Natural England. This suggests making greater use of 'nature-based interventions (green care and ecotherapy) to help people suffering from mental ill-health.[258] See Appendix 1 for further information.

Employment and labour conditions

No one has attempted to calculate the cost to society from the declining agricultural labour force and the major changes in the type of work available over recent decades. It is clear however, that many of those who have lost employment opportunities in agriculture have moved to the cities where they increase the problems of urbanisation, housing shortages and pressure on local services, all of which clearly have a cost. This has also had an impact on the structure and viability of rural communities.

As a result, the only way in which most people can enjoy the therapeutic benefits of the countryside is through recreational activity. There are long waiting lists for allotments and despite the huge demand,[259] most people can only dream of finding some land on which to grow food themselves. Increased farm size and mechanisation have been the key drivers behind these trends.

In the UK, the agricultural workforce shrank by almost 20% between 2000 and 2010.[260] While amongst the lowest paid workers in the UK, working in agriculture has traditionally been fulfilling employment for a large number of people who are particularly suited to working with livestock or on the land. But with the move away from mixed farming to specialisation in either crop or livestock production, there are now few full-time jobs available and most of the demand is for seasonal workers, most of whom are now migrants. Many of these are day or seasonal labourers who are often paid less than national workers, have no job security and are not always paid when weather conditions prevent harvesting.

Rural communities previously had a large number of farming and farm workers' families which generally played an active part in rural life. In their place has come itinerant labour which is needed for seasonal tasks, but then not needed at all. Such workers have little opportunity to become integrated into rural communities and can be a source of local friction. There has always been some need for an increased number of workers at certain times of year, but with the exception of the war years, a much higher proportion of this was provided from within rural communities in the past when farms were smaller and such needs were less concentrated in small areas.

The situation on farms is also mirrored in some sections of the food processing industry. The Guardian recently exposed the reality of conditions for workers in chicken farms, abattoirs and processing factories.[261] High demand for cheap chicken from supermarkets has pushed often inadequately trained staff into working long hours for low pay. All of this leads to serious health care costs. In the UK since 2010 there have been 1,173 injuries to chicken processors reported to the Health and Safety Executive. Of these, 153 were classed as 'major', with one reported death. The reality is that worker exploitation has become common in agriculture due to the pressure to produce and sell cheap food.[262]

Cultural impacts of changes in agricultural production

As farmers have found it increasingly difficult to make a living on the land, and the agricultural labour force has declined, many traditional skills associated with the rural economy, as well

Farmers unable to make a living due to low farm gate prices are forced to sell up (Photo: Alan Wrigley / Alamy)

knowledge of local traditions, are at risk of being entirely lost. [263] This is compounded by the aging population of farmers (current average 59 years) and difficulties of attracting young people into rural and land-based careers, due to the lack of prospects, as well as the challenges faced by potential farmers trying to access land.

Buying land is extremely hard for most young farmers as prices have more than doubled in the last decade across all land types and prime arable land has more than tripled.[264] In addition, only a small number of farms are available to let, these are generally on short term tenancies which offer little encouragement to invest for the longer term, and many county councils are selling off their farms, though a small number are actually expanding their estates.[265]

There are many other impacts of intensive farming at a landscape level that are also hard to quantify, such as the ever-greater distances people need to travel to find landscapes and unspoilt countryside for leisure and to satisfy aesthetic or spiritual needs. Arable land in intensive crop production or cultivation allows for limited enjoyment by farmers, the local community and visitors from further afield compared to mixed farming systems for example.

Agroecological agriculture which integrates livestock with arable farming and increases the range of crops and livestock species is more likely to create a landscape which visitors can benefit from. Additionally, a farming system with higher biodiversity will be better equipped to stem the decline in seed and crop diversity which threatens food security[266] – yet another uncosted externality of the current food system.

9. POSITIVE EXTERNALITIES

"Converting low-intensity livestock grazing systems to intensive farming would mean losing not only species and habitats, but other benefits that extensively grazed pastures provide, like carbon sequestration and water quality. Furthermore, biodiversity provides critical services such as pollination and nutrient cycling: even intensively- farmed landscapes need some wildlife to function."

Royal Society for the Protection of Birds, UK Newsletter (2012)

Agriculture and the British countryside also provide a wide range of positive externalities. Attempts have been made to value some of these. In England and Wales the intrinsic value of broad habitat types and their associated landscapes was put at £593 million for non-SSSIs and £260 million for SSSIs in 2008, a total of £853 million or £1.026 billion at 2015 prices.[267]

Biodiversity and wildlife habitats

Studies on the value of biodiversity range from £10-35 million in 1996 in the UK[268] to £7.6 billion in England (2004) for the value of a 'high quality natural environment' and an additional £5 billion for environment-related tourist trade.[269]

The value of farmland bird species has been estimated at £307 million (£369 million in 2015). [270] One specific positive externality which has received significant attention in recent years is the value of crop pollination provided by both wild and domestic pollinators. In the UK, the value of insect pollination to agriculture has been estimated at between £400 and £690 million per year, **equivalent to a positive externality benefit of £0.63 billion in 2015** (based on an average of £545 million in 2010).[271] However, the practice of growing both arable and grassland crops as monocultures and the use of certain insecticides have been shown to have harmful impacts on pollinators, thus reducing the value of this positive externality (see Appendix 3).

Other benefits from farmland which have been costed in the US include the biodiversity of naturally-occurring soil organisms and microorganisms which can neutralise pollutants (a process known as bio-remediation; the control of pests in agricultural systems ($160 billion per year). Various wild insects, plant roots and fungi as food for humans have been valued at $180 billion per year.[272]

Soil carbon sequestration

Past studies by FAO and the IPCC have predicted that increasing CO_2 levels in the atmosphere will enhance plant growth and as a result increase soil carbon sequestration regardless of whether or not farming practices change.[273] These and other similar assessments have recently been challenged by a team from three Californian universities and other institutions. They calculate that while such increases may occur, this will happen much more slowly and be much smaller in extent than previously assumed because previous estimates failed to take account of the extent to which the warming climate will increase rates of carbon loss from soils. As a result, they argue, this will be of little benefit in addressing the immediate problem of the increasing levels of CO_2 in the atmosphere.[274]

Similarly, a significant number of scientists and organisations have promoted no-till crop establishment as a way of sequestering atmospheric carbon. A major review of the evidence in 2002 concluded that on average such systems could add 570 kg of atmospheric carbon to soils per hectare annually.[275] But at least four subsequent reviews of the evidence have concluded these conclusions were false, at least as far as soils receiving adequate rainfall are concerned. They point out that some of the claimed increases were miscalculated and that even where soil carbon does increase in the top 20 cm of soil it decreases by a similar amount between 20-80 cm in depth.[276]

Different teams of scientists have also come up with very different estimates of the carbon sequestration potential of grasslands. A recent multi-faculty study led by a researcher from the UN FAO in Italy, estimated that even with optimisation of grazing pressures, grasslands globally could only sequester 148 million tonnes of CO_2 (40 million tonnes of carbon) annually.[277]

In sharp contrast, in 2005 two scientists in the US estimated that grasslands globally were actually sequestering 200 million tonnes of carbon (733 million tonnes of CO_2) annually,[278] a broadly similar figure to that obtained by another scientist in 2004.[279] Whatever the truth about the global sequestration of grasslands, much of which is in dry regions where sequestration potential is minimised due to lack of moisture, soils under grass are acknowledged to be a major store of carbon, which has been built up over long periods. This is a positive externality of such farmland.

In addition, ley-arable rotations can maintain average soil carbon levels over time and increase them if sufficient farmyard manure is applied.[280] Provided all-grass farms are not over-stocked or fertility is allowed to decline, they also maintain and can increase soil carbon levels through net sequestration of atmospheric carbon dioxide.[281] More than 60% of UK farmland is under permanent pasture (if we include common land and rough grazing). In contrast to cropland, where soil carbon generally declines, permanent pasture retains and sometimes slowly increases this carbon store.

Based on data from multiple sites across the EU, scientists in France have shown that where stocking rates are not too high and fertility is maintained, European grasslands can sequester 760 kg of carbon per hectare per year.[282] It is generally accepted that such high levels will decline over time.

Hedgerows are valued by grazing livestock farmers for the shelter and boundaries they produce, and where fields are bordered by hedgerows the land either side of the hedge will contain approximately 75% more stored carbon than the middle of the field[283] while the carbon being locked up in the wood of hedgerow plants and trees can sequester approximately 450 kg carbon per ha per year with more than half of this potentially storable for up to 1,000 years.[k]

Nitrogen fixation

A significant example of an alternative approach to using nitrogen fertiliser, which illustrates the beneficial effects of healthy soils, is biological nitrogen (N) fixation. This is an important service provided by rhizobial bacteria which enables legumes such as clover to fix up to 224 kg N/ha/year.[284] At the current UK price of 34.5% nitrogen fertiliser (approximately £240/tonne) this is worth £156 per hectare. Globally the total annual contribution of N fixation by microorganisms in both agricultural and natural ecosystems has been estimated at 140 to 170 million tonnes of nitrogen and valued at $90 billion per year.[285]

Growing legume, like clover fixes nitrogen naturally, increased soil carbon and benefits biodiversity (Photo: Carter S / Flickr)

A further important function of soil microbiological life is the extent to which methanotrophic bacteria in the soil use 5% of atmospheric methane as an energy source,[286] a process degraded by ammonium-based fertilisers and the conversion of virgin land to crop production.[287]

Therefore, soil provides a wide range of direct and indirect economic benefits and the loss or degradation of soil is associated with substantial negative externalities or costs.

The problem with national figures for positive externalities is that the benefits rarely occur in the same fields or even on the same farms as the negative externalities. Figures on the positive benefits therefore, do not help to inform the debate about which systems are most and which least beneficial. Some approaches deduct all positive benefits from the costs of negative externalities, making it appear that agriculture has only a small problem in this respect.

That said, there are many positive externalities that could be encouraged which would bring benefits for society.

k Authors' calculation based on a 4-hectare field 200m by 200m, with hedgerows on all four sides and an oak tree every 50-metres. Calculation assumes that wood is 50% carbon, that 50% of carbon sequestration in trees and hedgerows is stored underground in roots and 50% in timber, that an oak trees reaches maximum above ground weight of 15 tonnes in 300 years, is felled after 500 years and 50% of the timber is used as building material; that the hedgerow is only lightly trimmed, laid every 20-25 years and that this yields 100 kg of wood per metre.

10. TRUE COST ACCOUNTING IN PRACTICE

"The idea of using the tax system, or some other form of charging, is definitely something we have explored and have ideas about in the pharma industry...And so why would it not be something that would be relevant for all those participants that are part of what in classic economic terms would be regarded as a market failure problem? If big food producers don't see that it's in their own enlightened self interest to shift to a more sustainable model then it will inevitably become a policy attraction at some point."

Lord Jim O'Neill, Chair of the Review on Antimicrobial Resistance 2014

For some time,[l] HM Treasury has provided guidance to government departments, including Defra, via 'The Green Book' of "the need to take account of the wider social costs and benefits of proposals, and the need to ensure the proper use of the public resource……attributing monetary values to all impacts of any proposed policy, project or programme".[288]

This being the case, one of the questions this report seeks to answer is why has so little progress been made in reducing the pollution, natural capital degradation and wider negative impacts on society of current food systems.

A comprehensive application of the guidance in the Treasury's Green Book is needed. The current approaches fall a very long way short of the mark. Payments to organic farmers, for example, for the first two years of conversion are reasonably generous, but after that they fall to just £30 (£12 per acre) per year,[289] grossly inadequate to compensate for the many ways in which such farmers either avoid or greatly reduce many of the negative impacts detailed in this report, meaning the business case for organic production hinges almost entirely on the extent to which consumers are willing to pay more for organic food. This limits the potential for expansion. At the same time, farmers producing food in ways which cause diffuse pollution of the air, water or soil make no contribution towards the costs which consumers pay directly or which the government pays on their behalf. From the early 1990s, since the lion's share of agricultural support under the Common Agricultural Policy was first paid on an area basis, no distinction has been made between farmers on the basis of their production externalities.

We have been unable to establish exactly why so little progress has been made. However, it seems most likely to be due to a combination of some of the following factors:

- The exclusive focus by policymakers on ecosystems at the expense of food systems, even though ecosystems are a component of food systems.
- Ambiguous words in the Green Book, phrases such as 'wherever feasible'.
- The lack of understanding of food systems within government circles and in the Treasury in particular.
- The complexity of the task. The Green Book states, 'the benefits of biodiversity can be difficult to measure, define and value'. The same applies to all food system externalities.
- The limitations of some of the evaluation tools:
  - Consumers 'Willingness to Pay' is one method used to value a benefit, but how can consumers make reliable judgement on this when they have little idea how much they are already paying in hidden ways?
  - Integrated Policy Assessments simply provide a check list of questions for almost all agricultural externalities.
- The requirement to carry out evaluations 'collaboratively between stakeholders', when most of those consulted will have been actively involved in agriculture.
- Residual reluctance within Defra to contemplate approaches which are

l At least one study (Bateman et al. 2009) cited above, indicates that similar wording was included in the Green Book in 2003.

radically different from those promoted for so many decades by MAFF (the Ministry of Agriculture, Fisheries and Food).

- The fact that food and agricultural issues span multiple ministries, departments and agencies, yet despite this and the vital importance of the issue, there is no cross-departmental body which sets food policy, for the benefit of all.
- The fact that food systems issues generally receive a low level of scrutiny and participation by the media except when there is a food crisis such as BSE or food contamination.

The basic principle of true cost accounting in food and agriculture has essentially been accepted by the UK Government, but so far only implemented to any meaningful extent in relation to nature conservation. Farmers are already being paid to restore wildflowers and traditional hay meadows or to provide habitat for endangered bird species.

Governments wishing to discourage environmentally damaging practices have a number of options open to them, including subsidies, regulation, tradable permits, policy changes and environmental taxes (See Appendix 2 for a fuller analysis of the issues and options).

Subsidies are perhaps the obvious place to start when considering financial incentives in the food supply chain, particularly in the context of the UK's expected exit from the EU. The UK's forthcoming subsidy programme must incentivise approaches which reduce air, water and soil pollution and degradation, generate lower net greenhouse gas emissions, reduce nitrogen fertiliser, pesticide and phosphate use, and which improve the nutritional quality of food.

As well as incentives, there are a number of market and fiscal measures that could reorient the burden of responsibility and accountability and shift the cost of unsustainable practices back to the perpetrator. Environmental taxes, for example, can effectively limit the use of certain practices or inputs, as well as providing revenue to the state in the form of environmental tax receipts - which can be used to incentivise improved practices.

According to the Office of National Statistics, environmental taxes are 'designed to promote environmentally positive behaviour, reduce damaging effects on the environment and generate revenue that can potentially be used to promote further environmental protection'.[290] In 2014 the UK Exchequer raised £44.6 billion by taxing practices which damage the environment; in 2016 £47.6 billion.[291] However, none of this related to agriculture, only 3-4% of the revenue related to pollution and resources, and the landfill tax accounted for three-quarters of this.

At the same time £14.7 billion was spent on environmental protection. While the UK tax revenue from environmental taxes has doubled since 1993, more than two-thirds of the revenue received is used to increase net Exchequer income rather than recycled to increase environmental protection still further, as it could be.

Nevertheless, the use of environmental taxes in the UK is now well-established and there is no reason in principle why these could not also be used to address some of the major environmental issues associated with the food system. In particular, we recommend that the government introduce a tax on nitrogen fertiliser, and use the funds to incentivise farmers to increase soil carbon. This is discussed in further detail below.

Tax measures can also be used to encourage sound farming practices and discourage less appropriate ones, for example through use of differential capital allowances for investments in appropriate infrastructure and sustainable technologies.

Other economic instruments could be harnessed to improve the 'market orientation' of certain food products (the extent to which consumer choice influences *what* food is grown, and *how* it is grown), for example through adjusting the VAT on certain products, in order to reduce or increase retail prices of some foods. Quantity-based economic mechanisms, such as cap and trade systems, constrain overall amounts of inputs or emissions, and are well-placed to tackle these issues on a global scale.

These kinds of financial incentives are not new. The Green Revolution was made possible by minimum market price support for crops, while inputs were highly subsidised. Large businesses already benefit from subsidies, low cost loans, or tax breaks - the intensive poultry industry in the US being a good example.

Post-Brexit food and farming policy must bring together the public and private benefits which come from managing land sustainably, and ensure that the right support and incentives are in place for this shift to take place. Clearly, policy coherence will be key. Strategies to drive progress must be aligned with other public policy areas such as trade, public procurement, health and climate change; to avoid scenarios where the introduction of policy measures offering limited sustainability benefits inadvertently causes greater adverse effects in other ways. The true cost approach will need to be fully integrated into the whole food and procurement supply chain, to ensure that consumers' money is not used to subsidise practices that are penalised through other market mechanisms.

The case for a tax on nitrogen fertiliser

The heavy use of nitrogen fertiliser has a number of adverse impacts, including pollution of the atmosphere and aquatic environment, the generation of ammonia emissions, and biodiversity loss. The introduction of a tax on nitrogen fertiliser could be achieved at no net cost to the Treasury. In addition, this would raise revenue which could be used to encourage farmers to adopt practices known to increase soil carbon sequestration - which has the potential to deliver significant environmental and economic benefits.

Approximately 3.5 million tonnes of nitrogen fertiliser is used in the UK each year. This contains 1 million tonnes of nitrogen. Unlike the nitrogen in the air we breathe, which is inert, fertiliser nitrogen contains reactive nitrogen i.e. nitrogen combined with either hydrogen or oxygen. Nitrogen also comes from livestock manures, but a high proportion of this also comes indirectly from nitrogen fertiliser through the nitrogen applied to the grass and other crops farm animals feed on.

The European Nitrogen Assessment, a major exercise involving over 200 scientists across the EU (many from the UK), established that the negative impact of using so much nitrogen fertiliser was between €35 and €230 billion in 2011. The top end of the range is much higher than previous estimates, largely because it considered a wide range of environmental and health impacts in substantial detail, whereas most studies before this had each tended only to look at one or two related issues and then generally only within individual countries. We do not have a breakdown of how much of the total estimated costs apply to the UK, but on a pro rata allocation, based on the fact that UK farmers use 8% of the nitrogen fertiliser in the EU, this could be as high as €18 billion in 2011, €20.23 billion at 2015 prices (or £18.41) billion at the August 2017 exchange rate.

Scientists involved with the EU Nitrogen Assessment have argued elsewhere that, 'Ideally, cost estimates for adverse effects of N_r (reactive nitrogen) should be used to internalize these costs, for example to charge the producer or consumer of N_r intensive products and to implement the "polluter Pays Principle"'.[292]

The UK has designated farmland in many river catchment areas as Nitrate Vulnerable Zones and introduced limits on how much nitrogen farmers can use per hectare in these areas. The amounts are only slightly lower than those typically used, but there is an inherent unfairness in that some farmers are expected to comply with these limits and develop management plans and maintain records, while other farmers outside these areas, with whom they are competing, are still free to use as much nitrogen as they wish. There is also a lack of environmental logic about this. The policy is largely aimed at reducing nitrogen pollution of rivers and drinking water in some areas. Yet as the European Nitrogen Assessment shows, this only constitutes part of the nitrogen pollution problem, which also impacts on GHG emissions, biodiversity, air pollution, urban landscapes, rural landscapes and more.

A study in 2006 by scientists from South Africa, France, Bulgaria and the UK concluded that taxes or tradeable permits issued free by governments would 'achieve the desired reduction of use with greatest economic efficiency because they allow greater flexibility than rigid kgN/ha limits'.[293]

Approximately half of all the nitrogen in nitrogen fertiliser is lost to the environment and not taken up by crops, so there is substantial potential for use to be cut without significantly affecting yields. While there are still considerable uncertainties within the EU Nitrogen Assessment's costings which make it difficult to establish the precise extent of the full externalised cost of nitrogen fertiliser use, its use brings commercial benefits to farmers on a sliding scale, with low application rates bringing the greatest commercial gain and excessive use the least. As such, even a modest tax on nitrogen would be expected to reduce excessive use, which would become less cost-effective.

Before they joined the EU, three countries, Austria, Finland and Sweden had introduced taxes on nitrogen fertiliser in order to do just this. But under single market rules such taxes are not possible within the EU unless all countries agree to adopt them. If the UK successfully leaves the EU, fresh consideration of the potential for a tax on nitrogen fertiliser would be merited. But the case for a nitrogen tax also needs making to the EU Commission, since many aspects of nitrogen pollution are not limited by national borders.

Introducing a small tax on nitrogen fertiliser would:

1. Generate funds that could be hypothecated to support schemes to reward farmers for soil carbon sequestration and stewardship;
2. Create a financial incentive for farmers to lower the levels of nitrogen which end up in intensive livestock units via feed and this in turn would reduce ammonia pollution; and/or
3. Increase use of forage and grain legumes which fix atmospheric nitrogen naturally and have soil quality and biodiversity benefits too.

The case for incentivising farmers to increase soil carbon levels

Even if significant progress is made in reducing GHG emissions, it will be necessary to find ways to remove some of the carbon already in the atmosphere if we are to keep global warming to below 2 degrees Celsius.

Increasing soil organic carbon levels is considered a win-win strategy with the potential to bring environmental and net economic benefits.[294] Soil organic carbon makes up approximately 50% of soil organic matter. Degraded soils retain less moisture and are therefore highly vulnerable to droughts.[295] But for every 1% increase in organic matter in soils the first foot of soil is able to hold an additional 16,500 gallons of water per acre (40,000 gallons per hectare).[296] The fact that soils with a higher organic matter can hold this extra water also reduces flooding, soil erosion during heavy rain, while increasing plant health and reducing the need for fungicides and insecticides.[297]

As such, one might expect most farmers to adopt the necessary practices to sequester soil carbon on a voluntary basis. This, however, does not happen because some of the practices, such as sowing cover crops, incur additional costs in terms of seeds and cultivation which are rarely recouped in full, as well as time delays which can impact negatively on the most profitable cropping rotations and systems.

THE 4 PER 1000 INITIATIVE

During the COP21 Paris Climate Conference in 2015, France launched the “4/1000 Initiative: Soils for Food Security and Climate” to highlight the role that agriculture can play in reducing and mitigating the impacts of climate change.[298] The initiative is based on the premise that a 0.4% annual growth rate in soil organic carbon content would help to reach the target of limiting the global temperature rise to 2˚C which the IPCC considers essential to avoid catastrophic climate change. The initiative contains a voluntary action plan that offers recommendations of courses of action for governments and local authorities, development banks and funders, and farmers and food producer organizations. These include suggestions to develop training programmes and policies for farmers and agricultural advisors to help them enhance soil organic matter and sustainable farming practices.[299]

Agricultural practices which either reduce soil carbon losses or increase net soil carbon sequestration have been extensively reviewed and include the reintroduction of grass breaks into arable rotations, the incorporation of crop residues, the return of livestock manures and organic waste to farmland, ideally after thorough composting, the use of deeper-rooting varieties, the avoidance of ploughing peat-based soils and agroforestry. The additional costs of these practices to producers are not, or not adequately, rewarded by the market to encourage their widespread uptake. The issue of zero tillage as a technique for sequestering carbon is seen by many agriculturalists and farmers as the only technique worthy of their consideration in this respect. However, a number of research papers have cast significant doubt over past claims made for zero tillage and soil carbon, see previous chapter.

Soil carbon sequestration clearly has a value to society in terms of its potential to remove carbon from the atmosphere and to make soils more resilient to weather extremes and help to ensure food security in future years.

In the UK, 12.2 million tonnes of CO_2 was lost from cropland in 2015 at a cost of £2.11 billion while 9 million tonnes was sequestered under grassland,[300] with a value of £1.56 billion, based on a putative social cost of carbon of $220 (£173) per tonne (see Greenhouse gas emissions and air pollution section in Chapter 2 for more on the social cost of carbon).

In 2015, a team of Scottish scientists posed the question, ‘Why is soil carbon management an economic issue?’ They answered, ‘The short answer is that it may be a relatively low-cost way of reducing emissions and governments might therefore want to prioritise it over other expensive ways of addressing climate change’, and they argue that this may need to receive financial support, potentially through agri-environment schemes.[301]

At the Paris Climate Change conference COP21 in 2015, the French Government launched a 4 per 1000 initiative, with the aim of increasing soil carbon levels by an average of 0.4% annually. Achieving this would require significant changes to food systems, which are not currently occurring. The UK signed up to the 4 per 1000 initiative but it is only a voluntary initiative.

Taxing nitrogen fertiliser and using the revenue to encourage greater use of carbon sequestration methods could be achieved at no cost to the UK Government or to taxpayers. Yet it would help the UK to meet its GHG emissions targets and bring a wide range of additional benefits which might be expected to increase the quality of life for many people and reduce the overall cost of food when both retail prices and hidden costs are included.

For a more in-depth analysis of the issues discussed in this chapter, see Appendix 2.

The case for integrating nature conservation with food production

Food systems impact on many components of ecosystems but the terms are far from synonymous and it is arguable that the focus on nature conservation, as one of the most high-profile components of ecosystems, has, to date, been at the expense of food system sustainability overall. This approach has also been extremely unsuccessful even judged against its own limited objectives. Countless studies and reports have found major declines in almost every aspect of wildlife in the UK occurring over recent decades when the policy approach has been land sparing rather than land sharing. The recent study on the decline in flying insects[302] is just one more example of this.

The policy approach has been to pay farmers large amounts of money to take small areas of land out of production and encourage them to intensify as much as possible on the remaining area, instead of encouraging food systems designed to allow food production and wildlife to coexist more harmoniously. The introduction of the set-aside scheme in the 1990s is a clear example of this, but it is not widely known that to make this possible, financially, a beef and sheep extensification scheme was dropped at the last minute under pressure from at least one major conservation organisation, even though Ministers had initially accepted the case for supporting a less intensive approach to grazing livestock production. We suggest that if these policy developments had been subjected to a rigorous interpretation of the Green Book guidance, different conclusions would have been reached about the best approach.

Mustard is one of many green manure crops that improve soil quality (Photo: Gary Naylor)

11. CONCLUSIONS AND RECOMMENDATIONS

The basic principle of true cost accounting has essentially been accepted by the UK Government, not just for food and agriculture, but in relation to all businesses. The Green Book, published by HM Treasury, requires all government departments to undertake "Analysis which quantifies in monetary terms as many of the costs and benefits of a proposal as feasible, including items for which the market does not provide a satisfactory measure of economic value."[303]

Why then does this report find that for so many issues the negative externalities are still alarmingly high? Some academics and policy-makers might say that all food production has negative externalities, and with the growing population this is likely to get worse not better. Professor Jules Pretty, one of the scientists who first brought these issues to public attention more than two decades ago, offers a more optimistic scenario in the Foreword to this report, with his belief that a new agricultural revolution is underway and that output in the future can be increased alongside decreases in the negative impacts of food systems. Wherever the truth lies, it is clear there is considerable scope for improvement and that some approaches to food production are preferable to others, even though in many cases they are less profitable within the current economic system, precisely because they internalize costs.

Despite this, over the last 20-30 years, a number of UK academics and campaign groups, in common with researchers globally, have attempted to assess the negative environmental and a few of the human health externalities of food systems. Some of these have just looked at single issues; a small number have attempted to pull some of the issues together in order to present an overall picture in relation to environmental externalities. In general, as time has gone on, each successive assessment has broadened the range of factors it takes into account and come up with a higher estimate than those which preceded it. We have given a specific illustration of this in the section on soil (see Soil in Chapter 2), however the point applies to almost all externalities.

In the past, Defra appears to have been more actively engaged with these issues than it is today, commissioning a significant number of studies. [304] Some past studies, for example, the Jacobs Report commissioned by Defra, with the devolved administrations,[305] have included some positive and some negative externalities. We need to be able to cost all positive as well as all negative externalities in order to compare one system or method with another. In this respect, and in relation to a number of negative externalities, further academic research is still urgently needed. As we explain in our Note on Methodology section, we have only been able to include figures for negative externalities for the food system as a whole in this report, because there is currently insufficient evidence to go further than this with any level of accuracy.

What has become very clear, however, is that there are some very high hidden costs in the food system which are significantly higher than previous composite estimates have suggested. With active consideration being given by many organisations and individuals to the type of food systems that will best serve our needs in the future it is important that this is more widely understood, with debate and decisions informed by the best available evidence at all times. We therefore urge the UK Government, the devolved administrations, Defra and all other government departments with an interest in the food system, to revisit their past work in monetizing food system externalities and give fresh impetus to filling in gaps in the data and using this as the basis for future policy development.

Adding up the hidden costs of food

Natural capital degradation

GHG emissions and air pollution	£12.56 billion
Climate change-related costs	*£9.69 billion*
Air pollution	*£656 million*
Environmental cost of transporting food to home	*£1.94 billion*
Melanoma skin cancer from ozone depletion	*£111 million*
Nitrous oxide	*£268.9 million*
Food waste across the total UK food system	£19.9 billion
Soil degradation including soil carbon loss	£3.55 billion
Water costs attributable to agriculture	£1.34 billion
Total	**£37.35 billion**

Biodiversity loss

Loss of British farmland biodiversity	**£7.8 billion**

Food consumption-related health costs

Cardiovascular disease, diabetes, cancer and dental caries:	£23.08 billion
Malnutrition:	£17 billion
Overweight and obesity:	£3.86 billion
Hypertension:	£1 billion
Total	**£44.94 billion**

Food production-related health costs

Organophosphate pesticides:	£6.4 billion
Antibiotic resistance:	£2.34 billion
Food poisoning:	£1.8 billion
Colon cancer from nitrate in drinking water:	£43.5 million
Total	**£10.59 billion**

Farm support payment & regulation

Rural Development Programme, administration, regulation and research	£3.35 billion
Basic Payments Scheme	£2.95 billion
BBSRC food and farming research	£56.2 million
Total	**£6.36 billion**

Food imports

Net hidden cost of food imports	£9.29 billion

Calculating the hidden cost of UK food production

According to the Office of National Statistic's 'Consumer Trends' database, UK consumers spent a total of £86.08 billion on food and £8.44 billion on fruit and vegetable juices and other non-alcoholic drinks (excluding tea, coffee and cocoa), equivalent to a total of £94.52 billion in 2015.[306]

To get a more accurate figure for food spend, we need to include expenditure on catering services (eating out at restaurants, cafes and canteens). The same Consumer Trends data reveals that catering spend in 2015 was around £85.40 billion (£78.07 billion on restaurants and cafes, and another £7.33 billion at canteens).

Given that on average restaurants spend around 30% of their budgets on food, drinks and condiments,[307] it is appropriate to allocate 30% of the £85.40 billion spent on catering services – that is £25.62 billion - to actual 'catering food spend' in 2015.

This gives us a rough figure of **£120.14 billion spent by UK consumers on food and non-alcoholic drinks** in 2015.[m]

Hidden externality costs identified by this report include:

- Food consumption-related health costs £44.94 billion
- Food production-related health costs £10.59 billion
- Natural capital degradation £37.35 billion
- Biodiversity loss £7.8 billion
- Subsidies and regulation £6.36 billion
- Imported food £9.29 billion

This gives us a total of £116.33 billion.

As such, this report concludes that for every £1 UK consumers spend on food they pay additional hidden costs of approximately another £1, which they pay in other ways than in purchasing food.

The total costs calculated in this report are unlikely to be an over-estimate, as we have not included any costs for some areas where costs can clearly be seen to exist, but where there is insufficient evidence to apportion these accurately.

m See footnote ii

Main policy recommendations for the UK Government

1. All aspects of UK agricultural policy post-Brexit should be underpinned by an appraisal of the true costs and benefits of different food production systems and techniques.
    a. This should be informed by further research which is regularly updated into agriculture and food-related externalities.
    b. Agricultural policy should be developed using integrated approaches which increase diversity and resilience in food systems.
2. Public subsidies should be redirected in a way that will discourage environmentally damaging practices, and encourage food systems, practices and foods which bring genuine public and environmental benefits.
    a. Set against hidden costs of £1 for every £1 spent paid by consumers, the cost of agricultural support schemes of 2.5p appears very modest. However, at present very little of this money goes towards improving the environmental sustainability of agriculture. As such, there is a strong case for increasing, rather than reducing the current level of public subsidy to agriculture, but using all of this to reform food systems in ways which reduce the other, much higher hidden costs paid by consumers and society.
    b. While it is essential to reverse the decline in UK farmland biodiversity and natural capital degradation, agricultural productivity also needs to be maintained in order to reduce the demand for imported food, the production of which can result in even greater environmental degradation elsewhere. Increasing soil carbon and through that stable organic matter content is the primary way to make soils more resilient to climate change and productive in the future.
3. Consideration should be given to the use of taxes on the most damaging agricultural inputs.
    a. A key example could be the introduction of a tax on each tonne of nitrogen fertiliser, with the income raised used to compensate farmers for the additional costs involved in adopting practices proven to increase soil carbon sequestration and storage.

Other recommendations

Action is needed at multiple levels across the food system, from politicians, policy-makers, NGOs, citizen-consumers, scientists, food businesses and investors.

Campaign organisations and policy-makers

- Avoid, wherever possible, promoting solutions to single problems and instead recognize the value of integrated approaches and of true cost accounting in establishing which approaches are most beneficial.
- Develop campaigns which encourage businesses and policy-makers to improve transparency and be straightforward about the true costs of food production.
- Recognize that agricultural subsidies account for a relatively small proportion of the hidden costs paid by consumers and that cutting the total amount of subsidy provided to farmers in the UK – at a time when we need those systems to change – would be highly counter-productive as it would increase intensification and farm size still further, as well as increasing food imports.
- Increase opportunities for individuals to experience the therapeutic and other benefits of working with farm animals and on the land growing food crops.

Citizen-consumers

- Demand increased transparency from the food industry about the hidden and true costs of food.
- Support campaign groups which are attempting to reform the UK food system.
- Likewise, give support to those advocating global food system change to ensure food imports are sustainably sourced.
- Where possible, support market-led initiatives which make food healthier and food production more benign.
- Scrutinize health and nutrition claims with care and ensure that healthy diets are also compatible with sustainable production.
- Demand, from both national and local government, increased opportunities to grow your own food or gain on-farm experience.

Food industry and the business sector

- The retail sector needs to make itself fully aware of the true cost of the food that it sells. In a post Brexit era, it must be proactive in demanding food and farming policies that ensure that its supply-chain partners are producing food that is genuinely sustainable from the perspective of the environment, the farmers and the rural community.
- Likewise, the food service and food processing sectors; sustainable must become more that a tick-box word. They must produce foods that have minimal to no hidden costs, be they for the environment, for human health or for their farmer-suppliers.
- Support the transition towards better, more resilient and less costly (as per true-cost accounting} practices within the farming industry and wider food systems.

Scientists and researchers

- Undertake research which focuses on outcomes that take account of the true cost of food, updates existing data on the externalities of food production, and fills in gaps in the literature related to food and agricultural externalities, including the wide range of social and cultural impacts.
- There is a particular need for further research into the total costs of biodiversity loss from agriculture, its individual components and causes; the impact of pesticide use on water industry costs borne by consumers; and the health and environmental costs of reactive nitrogen from agriculture and the effectiveness of current policies.
- Seek funding for independent research which delivers food system solutions that increase resilience and reduce reliance

on approaches with high negative externalities.

- There is an urgent need for additional research on the links between diet and dementia, including the extent to which method of production influences micronutrient context in ways which could increase the potential risk of dementia.

Funders and investors

- Increase support for projects which aim to research, campaign for, and raise awareness about the true cost of food and agriculture, and propose solutions to reduce the high cost of negative externalities in a sustainable way.
- Recognize that food systems are complex and that funding which encourages integrated rather than single solutions to multi-dimensional problems will be the most cost-effective approach.

Food producers

- Embrace all current subsidy opportunities to make production systems more sustainable and show support for new agricultural policies based on true cost accounting.
- Recognize that the current food system is not working for farmers and is degrading the assets upon which future productivity and prosperity depend. Farmers should play a central role in demanding agricultural policies which produce a fair and equitable food system. They should resist pressures from supermarkets and elsewhere to outcompete their neighbours through an endless spiral of intensification and expansion, because this is ultimately self-defeating.
- Increase diversity in rotations and where possible integrate crop and livestock production.

APPENDIX 1

Food affordability

One question which arises is: if we were to introduce true cost accounting into the food and agriculture sector, would food prices increase and what would this mean for those already experiencing food poverty? The answer has several components.

1. Food prices are influenced by many factors. They have risen over the last year in the UK due to the fall in the value of the pound; they have also risen in recent years due to poor harvests in other countries, and it is widely predicted that climate change, declining soil fertility and crop and livestock diseases will cause ‘shocks’ to the food system in future years which are likely to impact on prices.
2. If the Government accepted our recommendations and, for example, introduces a tax on nitrogen fertiliser and used the money to pay farmers to increase soil carbon, this would probably increase costs for intensive crop producers and put up some prices. This would increase the price of intensively produced grain-fed meat, but the increased support for those looking after the soil would mean they would be able to produce food more sustainably, so the cost of more sustainably produced food would fall.
3. In the longer term, however, fields with high organic carbon content would be better able to resist droughts and floods and would ultimately produce higher yields which would have a downwards impact on prices.
4. If we compare conventionally-produced food with, for example, organic food, we might expect, after the comprehensive introduction of true cost accounting, that the former would rise and the latter fall, ending up somewhere between the two and creating a level playing field which allowed consumers to make choices on quality rather than price.
5. But we need to recognize that even quite significant increases in farmgate prices of many commodities would have only a very minimal impact on retail prices. The farmgate price of wheat, for example, represents only about 5% of the cost of a loaf of bread. Therefore, even a 25% increase in the wheat price would only add a few pence to the cost.
6. Unless food producers are paid a fair price they will be forced to continue mining natural capital, which will ultimately undermine the viability of food systems and lead to runaway food prices at some future point.
7. To the extent that food prices may rise, we would expect the hidden costs in the food system to decline, leaving consumers on average no worse off. There could though be glitches, which may temporarily affect some sectors of society more than others.
8. It is interesting that in the post-war period, when the cost of food represented a very much higher proportion of average incomes, and the incomes of the poor, than it does today, there was less serious food poverty. As such it can be deduced that driving down the price of food does not necessarily benefit the poor. This may be because the hidden costs we all pay only increase as a result.
9. While it would only help a section of society, making more land available for allotments would give more people a chance to grow their own food. Similarly introducing schemes to stimulate more production of fruit and vegetable and other foods that are marketed locally would give more people an opportunity to make savings on food purchases, but buying direct from producers.
10. However, the government must ensure that low income social groups are protected from price rises by investing in policies to tackle food poverty and to improve access to good quality food. For example, the Supplemental Nutrition Assistance Program in the US provides food-purchasing assistance for low income individuals, and the Scottish government is considering enshrining a ‘right to food’ into law.

APPENDIX 2

Policy levers and ways forward

To bring about true cost accounting there needs to be a significant shift in political will towards initiating a combination of policy approaches that will address the flawed agricultural economic system.

Environmental policy instruments

There are a wide range of policy levers available to governments for reducing the negative externalities of agriculture and supporting sustainable farming systems that have a lower 'true cost'. Taxes and government regulation are not the only choice available, although they are often the most cost-effective and powerful levers. Information campaigns, fines, labelling systems, voluntary agreements, tradable quota permits, and transparency and information disclosures, among many others levers, can all be part of the mix and be used to restrict certain practices and encourage others. Table 3 provides an overview of many of these levers.

Table 3: Overview of a range of environmental policy levers (adapted from Sterner and Köhlin)[308]

Fiscal measures	Regulation	Information	Creating rights
Taxes	Bans	Information disclosure	Tradable permits
Subsidies	Zoning	Voluntary agreements	Tradable quotas
User charges / pricing mechanisms	Permits	Labelling / certification schemes	Offset systems
Deposit-refund systems	Public goods	Media campaigns	

Taxes

A tax on pollution, pesticides and emissions, or a tax on inputs that generate GHG emissions such as artificial fertilisers, would provide revenue to the state as well as reducing the amounts of fertiliser and pesticides used. However, setting a tax to achieve the socially optimal level of pollution is very difficult, for both technical – it requires regulating authorities to have carried out detailed economic modelling – as well as political reasons.[309]

In the UK, environmental taxes raised a total of £44.6 billion in 2014, with over 60% from fuel taxes alone, which accounted for 7.5% of all revenue from all tax sources and social contributions.[310] Environmental taxes as a share of GDP have remained relatively stable for over 20 years at between 2% and 3% of GDP (2.5% in 2014). Pollution and resource taxes, including the extraction of raw materials and waste management, made up only 3.4% of total tax revenue in 2014. The landfill tax alone, which in a 2014 report on the 'Circular Economy' was described as "one of the most effective policy measures in increasing 'circularity' in the past decade,"[311] generated £1.1 billion in revenue, equivalent to just over three-quarters of all income from pollution and resource taxes.[312]

The US has almost no environmental or green taxes. Generally, the government relies on legal routes such as the Clean Air Act to control pollution from industry or the Corporate Average Fuel Economy standards to control pollution from cars. There are a handful of taxes to encourage fuel efficiency in vehicles such as the Gas Guzzler Tax imposed on inefficient cars, a tax on ozone-depleting substances, a tax on fuel (which is one of the lowest in the OECD), and a few taxes on pesticides. There is no federal tax on carbon, but a few counties have passed them including Montgomery County in Maryland and the town of Boulder in Colorado.

According to the OECD, regulatory and fiscal interventions such as taxes and subsidies are the most cost-effective policy levers available to government which can have a significant impact on public health. Food advertising, mass-media campaigns, school-based interventions and one-to-one counselling by doctors are all less cost-effective than top-down fiscal regulation (taxes). This logic can almost certainly be applied beyond the domain of public health to encompass environmental indicators as well (which, like air and water pollution, themselves have an impact on public health).

Table 4: Examples of environmental taxes (or exemptions) currently in use.[313]

Location	Item	Amount	Use
Washington (USA)	Hazardous substance tax (including pesticides)	0.7% of wholesale value	Funds are distributed to the Department of Ecology to help clean up and manage solid and hazardous waste in the state of Washington.
Minnesota (USA)	Aircraft use tax: agricultural planes used for spraying and dusting are exempt	6.5% of the amount paid for the aircraft or for aircraft parts.	n/a
USA	Diesel fuel tax: vehicles used on farms are exempt	0.0486€ per litre	All revenue except what is raised on train fuel is earmarked for highways and mass transit.
Florida (USA)	Severance tax on solid minerals (phosphate rock)	1.3377€ per tonne	n/a
UK	Landfill tax	£84.40 per tonne (standard); £2.65 per tonne (lower rate for soil and rocks)	n/a
UK	No vehicle excise duty on agricultural machines	49.6093€ per year	n/a
Netherlands	Non-point sources of water pollution (Manure). Arable farming, horticulture and very small farms are exempt, and up to 10 kg of phosphate surplus per hectare exempt	Surplus nitrogen above 40 kg/ha = 2.3000€/kg/ha; 0 - 40 kg/ha = 1.1500€/kg/ha; Surplus phosphate above 10 kg/ha = 9.0000€/kg/ha	n/a
Sweden	Pesticides	3.2958€ per whole kg active constituent	n/a
Bulgaria	Fee for excessive soil pollution: unit fee for mineral fertilisers	3.5741€ per m^2	20% of revenues directed to environmental fund are earmarked for environmental protection measures
Denmark	Duty of nitrogen used by households	0.6715€ per kg	

Denmark	Duty on pesticides: Non-point sources of water pollution - Pesticides	Chemical deterrents of insects and mammals = 25%; Deterrents of rats, mice, moles and rabbits = 3%; insecticides = 35% of retail value including excise duty but excluding VAT	100% used for environmental purposes and to compensate farmers etc. from the tax as it's primary objective is to reduce household consumption of pesticides
France	Water effluent charges: Non-point sources of water pollution: Pesticides	From €2 to €5.1 per kg, depending on the hazard and toxicity	Tax revenue is earmarked to water agencies
France	Water pollution from livestock	3.0000€ per livestock unit	Tax revenue is earmarked to water agencies

Fertiliser taxes have been introduced in Austria, Norway, Finland, Sweden, and a number of states in the USA with varying degrees of success: California and West Virginia both have a sales tax for farm-scale fertiliser ($0.00015/dollar of sales and 6% respectively), and a large number of states have taxes ranging between 4% and 8% for 'speciality' (smaller scale) fertiliser products.[314] European countries which had implemented a nitrogen tax had to abolish them when they joined the European Union's single market.

For example, Austria introduced a tax on fertilisers in 1986 as a means of raising money to support grain production, as well as conserving the soil. Rates were set at €0.25 per kg of nitrogen, then steadily increased until Austria joined the EU in 1994.[315] Rates of fertiliser use dropped from just below 400,000 tonnes in 1985, to around 240,000 tonnes in 1995. Consumption of fertiliser decreased by around 3% every year after the tax was introduced while fertiliser prices rose around 10% in total. While the direct environmental benefits may have been lower than these figures indicate, the tax stimulated an added benefit of raising awareness among farmers of the impacts of nitrogen fertiliser on the environment and wider human health, and encouraged them to use inputs more efficiently as well as utilising alternative sources of nitrogen, especially leguminous crops.

Denmark introduced a tax on nitrogen in 1998 that was set at 5 DKK ($0.74) per kg of nitrogen, although large farms are exempt since they are regulated through a quota system.[316] Pesticides are also subject to taxation, and depending on the type of pesticide can be as high as 35% of the retail value. In 2005, a tax on phosphate used in animal feed was introduced, and the money raised is ring-fenced and used to support farmers in paying their Municipal Property Tax (a form of land value tax). A study of the impacts of two different types of tax (the first a per-unit tax corresponding to 100% of the price of nitrogen in commercial fertilisers, the second also includes animal feed) found that reductions in fertiliser application were as high as 40%, resulting in reductions in nitrate leaching of around 20%.[317]

There are a number of advantages to taxes as an instrument to encourage behaviour change and reduce fertiliser externalities. For a start, taxes are relatively easy to apply, compared to monitoring nitrate levels in water and ammonia emissions from soils where fertiliser is applied and intensive livestock farms. They offer a powerful and continuous incentive for change.

A recent study modelling the impact of a carbon tax on food combined with a 20% sales tax on sugary drinks, found that this would have significant health benefits as well as generating approximately £400 million in revenue.[318] Tax packages that have the greatest impact on externalities are generally considered to be those that are combined with other policy instruments such as subsidies and regulations. This is certainly the case with the proposed 'soda tax' or 'sugary drinks tax' that has received increased policy and widespread media attention in recent years.[319] Studies have shown that taxing 'less healthy' foods and using the revenue to subsidize the price of fruit and vegetables would have the greatest impact on public health.[320]

Consumption taxes, levied on products that generate pollution and emissions in their production, can also help reduce negative externalities (on the environment and human health).

Subsidies and agricultural support

Subsidies are an important tool for protecting businesses from both the cost of the negative externalities they produce, as well as the potentially unfavourable markets they operate in. The value that businesses and certain activities provide to society and the environment can be significantly distorted through the provision of subsidies. For example, subsidies for the production and consumption of fossil fuels were estimated to be worth around $5.3 trillion (equivalent to $10 million very minute) in 2015, around 6.5% of global GDP.[321] It is estimated that removing these subsidies would reduce CO_2 emissions by more than 20% and reduce the percentage of premature global air pollution deaths by 55%.

In addition, some states and counties in the US provide financial support to encourage the development of new food processing facilities such as slaughterhouses and packing plants and the associated new confined feeding operations that are needed to supply them. For example, Mason City in North Carolina, USA, has recently proposed offering an estimated $14 million tax rebate and about $13 million in incentives to encourage Prestage Farms to build a 650,000-square-foot pork processing plant.[322]

Since the 1980s, agricultural policies in the EU and US have been decreasing support for market-distorting commodity prices, and increasing in support in other ways, including decoupled payments, agro-environment policies, rural development, extension and innovation.

Direct spending comparisons of agricultural support levels between the EU and US are not straightforward, because of the structural differences in their respective farm sectors: the US has more than double the farmland base, while the EU has more than six times the number of farms. Therefore, EU expenditure per hectare is higher than in the US, while US expenditure per farm is higher than in the EU.[323]

In the past few years, both the EU and US have placed increasing emphasis on agro-environment policies (AEPs) where farmers are offered payments in exchange for implementing management practices that are beneficial for the environment. These include the Conservation Title of the Farm Bill in the US and most of Pillar 2 and cross-compliance of the EU Common Agricultural Policy (CAP) – as a response to the Uruguay Round to comply with WTO provisions, and to improve the environmental sustainability of the agricultural sector. However, both in the US and the EU, financial resources dedicated to AEPs are still a small percentage compared to the income support under the Farm Bill and the 1st Pillar of the CAP. In addition, while such schemes have generally been encouraged and welcomed by campaign organisations within the EU they have also faced some criticism for the limited scope of their design and failure to achieve their objectives.[324]

While motivated by similar concerns, the US and EU approaches to AEPs are quite different. In the EU, the relationship between agriculture, the environment and rural development represents the foundation of the European model of multifunctional agriculture.[325] While the bulk of US AEPs target the reduction of negative externalities of agricultural production (in particular soil erosion and water pollution), AEPs in the EU have the additional objective to use agriculture as a driver of rural development and compensate farmers for the provision of positive externalities (e.g. attractive landscapes, quality food, biodiversity conservation).[326]

Farmers in the US are often specifically paid to return farmland to its natural state, because land is perceived to attain higher environmental value when it is taken out of farming;[327] European policy aims at limiting land abandonment and retaining the 'rural' character of the European countryside.

While the US approach is considered too narrow in scope and has been criticised for not preventing land abandonment in extensively managed and low profitable farmland,[328] poor targeting is considered the main weakness of the EU approach,[329] which reduces agriculture's potential to deliver positive externalities.

The most successful stories of agro-environment schemes in the EU suggest that targeted options, both spatially within the landscape and when implemented with practical management guidance and advice for farmers, can provide significant ecosystem services.[330] It is also vital that farmers, as key stakeholders who implement agro-environment schemes on the ground, are actively involved in the design process of the schemes. Cost-benefit analysis can be used to provide guidance for land management options and policy priorities.

Large businesses often benefit, not only from subsidies, but also from tax breaks and other forms of support. The intensive poultry industry in the United States, for example, receives tax breaks, low cost loans, workforce training grants and reimbursements.[331] According to Oxfam America, since 1995, Tyson, the American food processing company, have received around $129 million in tax credits and incentives.

Government policies can be developed to encourage financial investment in sustainable agriculture and agricultural technologies that will reduce the impact of negative externalities and increase positive ones. Policies can also be developed to remove or reduce the barriers faced by smaller-scale sustainable production systems by for example, modifying the current commodity crop subsidy system that discourages farmers from diversifying their crop production; increasing access to micro-lending and grant schemes which support sustainable farm businesses; and – in the US – modifying federal crop insurance programmes so that they can support smaller-scale, diverse farms that use sustainable practices.

Regulation

Zoning and land use regulations, as well as bans and permits for controlled or limited activity, are powerful ways of affecting the behaviour of businesses. Through zoning, agricultural land can be protected and retained within a community as productive land serving the food needs of the local area. Urban agriculture can be encouraged through zoning to help support the economic, health and environmental needs of urban areas. Zoning can also be used to prevent both non-agricultural land use (housing or industrial developments) as well as unsustainable agricultural land use: for example zoning could specify the type of permitted agricultural activity allowed.

Information disclosure

Companies can be regulated to oblige them to keep track of, and make public, the positive and negative externalities related to their economic activities. This makes it easier for government and civil society organisations to make companies more accountable for the impacts of their activities, as well as acting as an incentive to encourage companies to reduce their negative externalities and increase their positive ones.

A European Commission directive on non-financial reporting, adopted in 2014, requires large public-interest entities (listed companies, banks, insurance undertakings and other companies) with more than 500 employees – of which there are nearly 6,000 – to report policies, main risks and outcomes relating to environmental, social, and human rights matters.

Labelling and certification

Labels and certification schemes are widely used as a means of increasing product transparency through voluntary regulation, and encouraging behaviour change, both from the consumer and the producer end. Labeling and certification also provide an opportunity to create a niche market for a product, sometimes for a premium price. Examples range from organic food labels and other sustainable farming certification such as Marine Stewardship Council for fish and the Roundtable on Sustainable Palm oil for palm oil production, to natural resources management of forests with the Forest Stewardship Council and the standards set by the Electronic Industry Citizenship Coalition.

Carbon labelling, which allows consumers to see the total amount of carbon released during the lifecycle of a product (the carbon footprint) is a powerful means for informing people of the impact of their purchases on the environment. After an initial period of success, with a major UK supermarket retailer – Tesco – committing to put carbon labels on 7,000 products in 2007 and several other companies also using the label, carbon labelling has suffered from a perception of being expensive to implement and overly complicated to calculate. In 2012, Tesco, which was the largest supporter of the Carbon Trust Carbon Reduction Label, dropped the use of carbon labelling blaming the lack of take-up from other retailers, as well as the long time needed to calculate each product footprint. While it is clear that increasing the amount of information consumers have about the environmental and social impacts of the products they consume is a positive thing, there are concerns about both the methodology of carbon labelling, as well as doubts about how much impact they can have on modifying consumer behaviour:[332] Traffic light labels of the kind used to warn against products with high sugar or salt are considerably simpler to understand.

APPENDIX 3

Insect pollination and pesticides

Background

Approximately 75% of the world's food crops depend in part on insect pollination. However, wild pollinators are increasingly threatened by a range of factors including land use change, intensive agricultural practices – especially monocultures, increased use of insecticides and fungicides, and climate change. The United Nations has stated that around 40% of invertebrate pollinators (including bees and butterflies) are facing extinction.[333]

Evidence suggests there have been large reductions in the diversity and quantity of wild and managed pollinators across Northern Europe, including bumblebees, honeybees and butterflies.[334] In England, honeybees declined so much that they were only capable of supplying 34% of pollination demands in 2007 compared to 70% in 1984.[335] If this trend continues, it will have severe economic implications because insect pollinated crops cover approximately 20% of UK cropland, and account for 19% of total farmgate crop value.[336] Loss of pollination services would inevitably reduce the yields of many food crops. It is doubtful whether sufficient workers could be found to undertake the skilled and laborious task of hand pollination in the UK as has been needed in parts of China, but even if this were possible there would be a huge increase in labour costs.[337]

A growing body of research suggests that pesticides, principally neonicotinoid insecticides, are having a detrimental impact on pollinating insects, particularly on wild and honeybee populations. Insecticides have been linked to colony collapse disorder in honeybees.[338] In the winter of 2006-7, more than a quarter of the United States' 2.4 million bee colonies were lost to colony collapse disorder.[339] A study from researchers at the University of Maryland has also found evidence that fungicides (previously considered safe for bees) increase the risk of infection by the bee disease Nosema.[340] If confirmed, this could be of additional significance since in many countries farmers are permitted to spray fungicides during bright daylight hours when bees and other pollinators are foraging.

Even without the use of pesticides, agricultural intensification and monocultures pose huge problems for the survival of pollinating insects, farmland birds and other wildlife. For example, oilseed rape provides large amounts of food for insects when the plants are flowering, but nothing at all once flowering is over. Bumblebees are more important pollinators of some crops than honeybees, but some have a flying range of only a few hundred metres and cannot survive if they do not have continuity of nectar sources within that range. Traditionally, pollinators would have relied on wild flowers, weeds and legumes like clover in pasture fields during lean times, but in many areas these are now essentially non-existent.[341]

Benefits of pollination at risk from intensive agriculture

The global annual economic value of insect pollination was estimated to be $167 billion during 2005, corresponding to 9.5% of the total economic value of world agricultural output considering only crops that are used directly for human food.[342] It has been estimated that if pollinators disappeared, up to 56% of people in developing countries could be at risk of malnutrition.[343]

Professor Dave Goulson from Surrey University, writing in the Financial Times, claimed that 1.5 million hives of bees are needed to pollinate the almond crop in California, and with many bee keepers losing hives faster than they can be replaced, rental costs have tripled to $160 per hive just for the pollination period,[344] something which may have contributed, along with drought, to recent increases in the price of almonds.

Given the aspirations of many large farmers to grow even bigger and to intensify food production further in a post-Brexit UK, and continued pressure from the agrochemical industry and bodies like the National Farmers Union to lift the ban on neonicotinoids,[345] there is a real risk that the positive externality pollinators currently provide will become a negative externality or cost to the UK farming economy. If pollination services are lost around the world, the real cost to society, from the loss of food security, is impossible to calculate.

APPENDIX 4

Organizations working on true cost accounting

A number of organizations are already working on true cost accounting, by commissioning or carrying out research aimed at putting a cost on the externalities associated with food production, as well as campaigning to raise awareness about the importance of true cost accounting among policy-makers and business leaders.

These include:

- **The Economics of Ecosystems and Biodiversity (TEEB) for Agriculture & Food:** Led by the United Nations Environment Program TEEB office, this project aimed to bring together scientists, economists, policymakers, business leaders and farmer organizations, to undertake a comprehensive economic evaluation of agricultural systems and to develop policy scenarios that would enable a transition to more sustainable agricultural practices.[346] The interim report focused on five sectors – livestock, rice, agroforestry, inland fisheries, and palm oil – examining the 'true cost' of each sector in terms of the full range of impacts and dependencies.[347]
- **UK True Cost Accounting Working Group:** Convened by the Sustainable Food Trust, the UK TCA working group has brought together over 25 different organisations with an interest in identifying, quantifying and, where possible, monetising externalities arising from our current agricultural systems.
- **Global Alliance for the Future of Food (GAFF):** GAFF is a foundations collaborative that aims to strategically leverage resources and knowledge, develop frameworks and pathways for change, and push the agenda for more sustainable food and agriculture systems globally. Their Externalities Working Group aims to make visible the full costs of producing food by investing in efforts to identify, measure and value the positive and negative environmental, social and health externalities of food and agricultural systems, and to deploy innovative strategies to affect associated policy and market change.
- **Compassion in World Farming (CiWF):** In January 2016, CiWF outlined the human health, environmental and animal welfare costs associated with industrial livestock production.[348] They concluded that since we pay for our food three times, once as shoppers when we buy food, again through our taxes which fund the Common Agricultural Policy, and finally as taxpayers paying for the damage caused by industrial agriculture, we need to rapidly move to sustainable forms of food production and 'halt the depredations of industrial agriculture' which currently come at such a high hidden cost. It suggests the introduction of a Pigouvian tax on food producers (taxes levied on market activities that generate negative externalities) equivalent to the cost of the negative externalities, with money raised from taxation used to incentivise farmers to generate positive externalities.
- **Food Tank:** In November 2015, Food Tank released its report 'The Real Cost of Food' summarizing findings from a range of analyses and case studies.[349] It offers a powerful call to action to businesses, civil society, consumers, food producers, funders and investors, policy-makers and researchers, suggesting interventions at every level which will help to mitigate the damage caused by our unsustainable food system, and highlights the importance of shifting to an economic system that internalizes the externalities of food production.
- **International Panel of Experts on Sustainable Food Systems (IPES):** In June 2016 the IPES released a report, 'A paradigm shift from industrial agriculture to diversified agroecological systems', focusing on the true cost of industrial agriculture and a theory of change. This report is helping inform the aforementioned Global Alliance study and is a group we hope to work closely with in future.
- **Nature & More (Eosta):** As a food business, Eosta has engaged with true cost accounting by launching an initiative specifically geared towards making the true cost of food visible to customers.[350] So far it has carried out studies on 8 commonly consumed foods.
- **Natural Capital Coalition:** The coalition is a global collaboration across business, accountancy, science, and organizations involved in policy and conservation, to develop methods and protocols to help businesses measure and value natural capital. Given the growing understanding of the benefits of conserving and enhancing natural capital to both business and society, the Coalition has produced a series of guides for different sectors of the economy, including one on 'Food and Beverage'.[351] The ultimate aim of these guides is to encourage businesses to strengthen the case for the use of natural capital assessments by continuing to measure and value natural capital, integrating information about natural capital with other aspects of business management, and continuing to develop knowledge.
- **International Federation of Organic Agriculture Movements (IFOAM):** IFOAM, together with the Sustainable Organic Agriculture Action Network (SOAAN), has been working to review and synthesise the science related to true cost accounting, with a view to publicising its results and developing tools and recommendations within and beyond the organic sector.
- **IAP:** The IAP recently conducted a study in conjunction with SEKEM entitled Comparative Full Cost Accounting Study of Organic and Conventional Food Production Systems in Egypt. Patrick Holden (Chief Executive of the SFT) will continue to attend these meetings and take part in advisory calls.
- **Trucost:** Founded in 2000, Trucost has been quantifying economic externalities related to corporate value chains, sectors and regions.

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Sustainable Food Trust

A global voice for sustainable food and health

The Sustainable Food Trust is a UK based charity working internationally to accelerate the transition to more sustainable food systems.

We believe radical changes are needed to address the problems of farm-related environmental degradation and biodiversity loss, food security and diet-related disease, but this will only be possible when leaders and organisations are empowered to act through a combination of sound evidence and enabling policy measures, supported by pressure from informed public opinion.

We are committed to facilitating a transition away from the current industrialised food model, to food systems which are more diverse and integrated, minimise depletion of natural resources, and promote public health, social justice and human wellbeing.

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HIDDEN COST FOODS

UNITED KINGDOM

NATURAL CAPITAL DEGRADATION

GHG EMISS + AIR POLLUTION	£12.56 BN
FOOD WASTE	£19.90 BN
SOIL DEGRADATION	£3.55 BN
AGRICULTURAL WATER	£1.34 BN
	£37.35 BN

BIODIVERSITY LOSS

LOSS FARMLAND BIODIVERSITY	£7.80 BN

FOOD CONSUMPTION-RELATED HEALTH COSTS

CV/DIABETES/CANCER/DENTAL	£23.08 BN
MALNUTRITION	£17.00 BN
OVERWEIGHT + OBESITY	£3.86 BN
HYPERTENSION	£1.00 BN
	£44.94 BN

FOOD PRODUCTION-RELATED HEALTH COSTS

ANTIBIOTIC RESISTANCE	£2.34 BN
FOOD POISONING	£1.80 BN
ORGANOPHOSPHATE PESTICIDES	£6.40 BN
COLON CANCER FROM NITRATE	£0.44 BN
	£10.59 BN

FARM SUPPORT PAYMENTS & REGULATION

RURAL DEVELOPMENT PROGRAMME	£2.35 BN
BASIC PAYMENTS SCHEME	£2.95 BN
BBSRC RESEARCH	£0.06 BN
	£6.36 BN

FOOD IMPORTS

NET HIDDEN COST OF FOOD IMPORTS	£9.29 BN

TOTAL TO PAY	£116.33 BN

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