

1 FOOD

How humanity is fed now and how we can do this better in the future. What can be done and what can everyone do?

We will start our tour of the big picture by looking at the global food system since food is the original source of energy for humans and is still as essential as ever.

Our land and sea need managing from many different perspectives at once. We need to feed a growing population with a healthy, tasty, low carbon diet. But we need to achieve this while preserving or improving the biodiversity that is currently haemorrhaging and despite the reductions in land fertility that we may be causing, not least through climate change. We also need to fend off pandemics, a looming antibiotics crisis and an explosion of plastic pollution that has crept up on us in just the past 50 years and is now with us forever as far as we can tell. As if all this wasn't enough, even though we don't really know how to do it yet, it is becoming increasingly clear that we will need land to have a role in putting carbon back in the ground. Oh yes, and we also need it for living space and recreation.

And these are just the human-centric considerations. How many readers will write me off as a hippy if I mention again that animals might also matter as sentient beings?

Luckily, for all the hideous complexity, it turns out that some relatively simple analysis makes a few important things very clear. Whether you are a food policy maker, a producer, a retailer or just someone who eats food, here are some big messages that I think everyone needs to know. They tell us a lot about what we can all do to help.

How much food energy do we need to eat?

About 5% of all human energy is still consumed in the most traditional way of all: through our mouths. On average we need 2,350 kcal (calories) per day, but we actually eat about 180 kcal more than that.¹

The average requirement of 2,350 kcal per day takes account of the different ages, genders, sizes and lifestyles of the world's population. It works out at 114 watts. For comparison, a big plasma TV needs a similar amount of energy and an electric kettle gets through about 15 times as much when it's on.²

How much food do we grow worldwide?

At the global level, we grow 5,940 kcal per person per day. That's nearly two and a half times as much as the 2,350 kcal per day that the average person needs to eat to be healthy.

Given these stats, you would think the planet Earth should be the land of food-plenty.

Regional variations are huge. North America grows a massive eight times its calorific requirement. In Europe and Latin America, the food grown is 'just' four times what humans need to eat. But sub-Saharan Africa grows only one and a half times the calories it needs.

You may well ask: why on Earth does anyone go hungry, and what do the Americans do with all their calories?

To find the answers to these questions we need to have a proper look at the journey from field to fork.

What happens to the food we grow?

Some 1,320 kcal per person are lost or wasted, 810 kcal go to biofuels and a massive 1,740 kcal are fed to animals.

(But meat eaters relax and read on. You don't need to go 100% vegetarian or vegan unless you want to.)

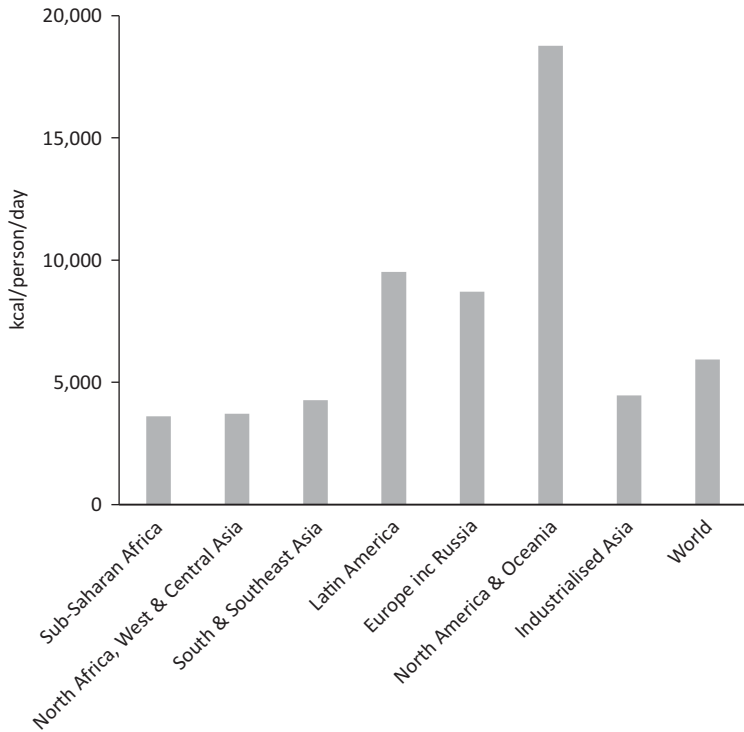


Figure 1.1 Plant-based human-edible food grown per person per day in different regions worldwide.

This simple chart cuts through the complexity of the global food and land system to give us a startling and essential perspective.³ All the numbers are in calories per person per day. I thought I already knew quite a lot about sustainable food having taken a keen interest for a decade or so, but crunching these numbers properly for the first time recently was a revelation.

Of the 5,940 kcal grown per person every day, here is what happens. Right at the start of the journey from the field to the stomach there are two kinds of waste; 340 kcal don't even get harvested. Some of that is down to over-fussy quality standards in developed countries, or gluts where supply exceeds

commercial demand and the food is shockingly left in the ground. Most, however, is down to harvesting inefficiencies, and while there is room for improvement, harvest loss is impossible to eradicate altogether. A further 330 kcal or so get lost in storage. This is mainly a problem in poorer countries and is often simply down to the lack of a sealed, dry container. At face value, there is plenty of scope for cutting this down.

Even after these stages, there are still a massive 5,270 kcal which are allocated in four key ways.

A small amount, 130 kcal, is replanted. This is a good idea because it means we can eat next year as well. And 810 kcal go

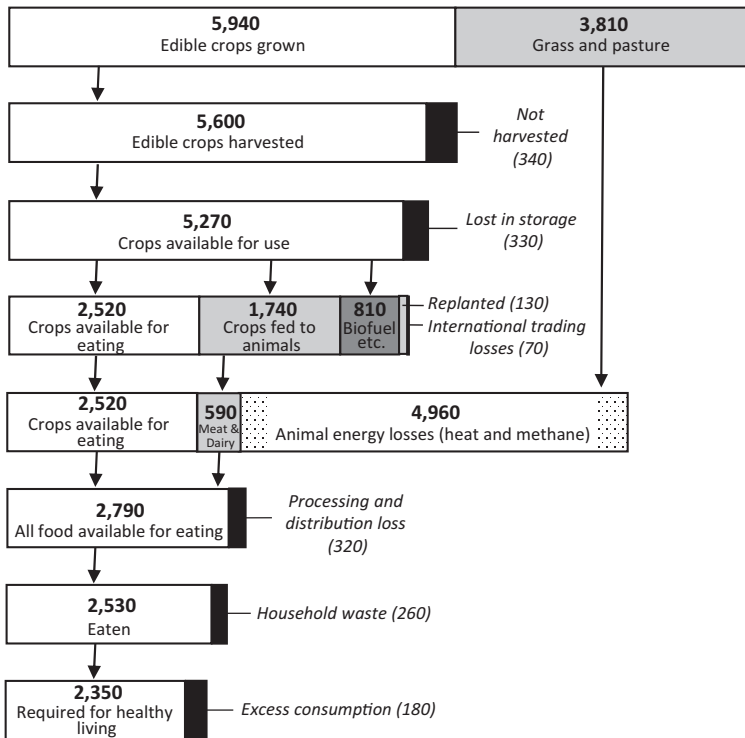


Figure 1.2 The world’s food on its journey from field to stomach. Numbers are in kcal/person/day.⁴

to non-food uses, which is mainly biofuel. Animals eat a massive 1,740 kcal. That still leaves 2,520 kcal of plant matter for human eating.

After that there are some relatively small losses in distribution and food processing, and then households waste a good chunk more. In the end, including the meat and dairy, the average human eats 2,530 kcal, which is 180 kcal more than the average person needs for a healthy diet.

Given the global surplus, why are some people malnourished?

When this happens, it is almost always because they can't afford, or don't choose, a healthy diet.

Although there is significant net over-consumption at the global level, around 800 million people go undernourished (not enough calories) and a further 2 billion or so suffer some kind of 'hidden hunger' in the form of deficiency in protein or essential micro-nutrients, most commonly iron, zinc, vitamin A or iodine.⁵

One way of looking at it is that for everyone to have a healthy diet, four things need to happen.

- (1) Enough of every nutrient needs to be produced.
- (2) It needs to be transported to within physical reach of everyone.
- (3) Everyone needs to be able to afford it.
- (4) People need to choose to eat a good diet from the affordable options that are available to them.

Today, the first condition is already met. There is a 14% caloric surplus. With others at Lancaster University, I've done the same analysis for every other human-essential nutrient and found a similar story.⁶

Supply chains are capable of finding their way to anywhere in the world that can pay to make it financially worthwhile. So both the second and third conditions boil down to wealth distribution, which we will look at in more detail later on (see pages 130–139).

Taking all four criteria together and given today's food supply and population, there are just two critical factors for a healthy diet for all: it boils down to money and choice. Inequality is the main reason why anyone today does not have access to a healthy diet. Without sorting this out, it looks highly likely that there will always be hunger, whatever happens to the total supply. To be clear, when we come to look at wealth distribution we will find that the problem is to do with *relative*, not *absolute*, wealth.

Choice is of course a complex issue, combining education, culture, mental health and personal taste.

Importantly, nobody starves today for lack of food at the global level. The current problems are about how the abundance of nutrition is shared around.

Why don't more people explode from overeating?

Luckily, overweight bodies are less energetically efficient. Otherwise, many of us would.

If all of the net over-consumption of 180 kcal per day were translated into extra body weight, the average person would be gaining weight at about 8 kg per year.⁷ This would be disastrous in just a few years. Luckily, as a body gets overweight it gets less efficient, and burns through more energy just getting through the day.

However, if all humans were a healthy weight and eating only what they needed to maintain that, it would liberate food for a billion or so of the extra mouths that are coming our way.⁸ Clearly there would be other wellbeing benefits in parallel. Easier said than done, I know.⁹

We turn now to a closer look at the role of animals, which leaps out from the global food calorie flow map as a cause for concern.

How many calories do we get from animals?

Animals contribute 590 kcal to the human food chain as meat and dairy. BUT they eat 1,740 kcal per person per day of human-edible food as well as 3,810 kcal of grass and pasture.

The average farm animal converts just 10% of the calories it eats into meat and dairy foods. The rest is used up doing things like keeping warm, walking around, burping up methane and creating dung. While more than two thirds of all farm animal food are grass and pasture, which cannot be eaten directly by us, the human-edible crops that we feed them amount to more than three quarters of the calorific needs of the entire human population.

We can't eat grass and pasture, but some of the land currently dedicated to its production could be used for crops and some of the rest could be very usefully set aside for biodiversity.

In terms of efficiency, two rules apply. Firstly, the conversion rate is better when you don't kill the animal but instead take its eggs or milk. Secondly, if the animal doesn't have to keep warm, move around or live long then less energy will be wasted. Hence the efficiency of conversion is particularly low for beef (typically ~3%) but highest for eggs and milk (~18%). Obviously, and inadequately, this analysis has ignored any consideration of an animal as a sentient being.

How much do animals help with our protein supply?

They don't. The world's farmed animals destroy nearly three quarters of the protein that they eat, most of which comes in the form of human-edible food.

The average human needs about 50 grams of protein per day for a healthy diet and this is one argument that is sometimes used to defend the world's growing meat and dairy industry.

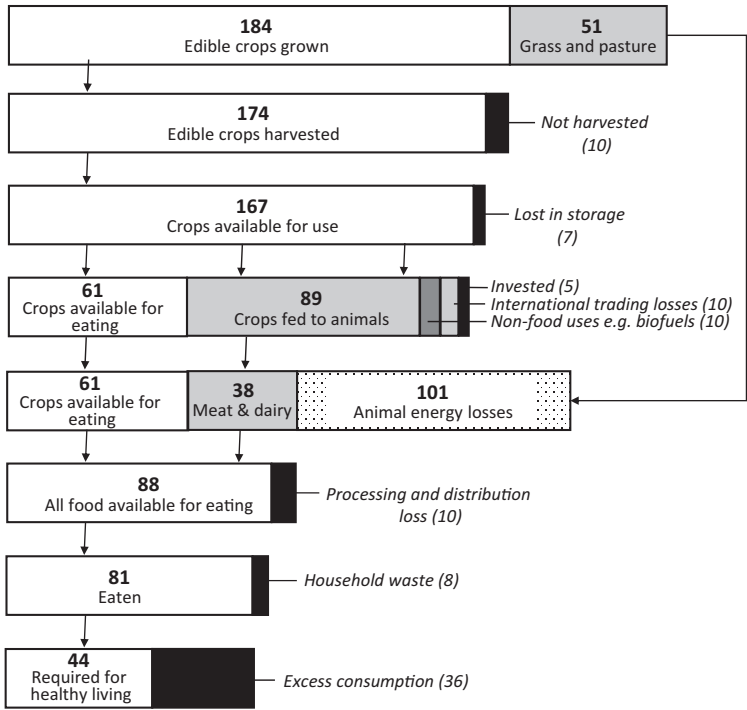


Figure 1.3 The journey of the world’s protein from field to stomach.¹⁰ Numbers are in grams of protein per person per day.

Protein can be tracked from field to fork in the same way as calories. When we do this, we find that a few myths can be busted. Firstly, we would have far more protein if we didn’t feed human-edible plant protein to animals. Secondly, the world has an even greater surplus of protein than it has calories. This last point is made more complicated by the fact that it is somewhat harder to distribute protein evenly than it is calories. Calories, unlike protein, are self-regulating to some degree. If a person regularly eats twice the calories they need they become extremely unhealthy in a very short time, whereas you can do the same with protein and not even know you are doing it.

Animals cannot, in fact, create all of the amino acids that proteins are made up of. There are nine *essential amino acids* that animals are only capable of storing or destroying.

Do we need animals for iron, zinc or vitamin A?

No. Animals reduce the iron and zinc supply, while 100 grams of sweet potatoes gives you all the vitamin A you need for the day.¹¹

Along with protein, shortages of these three nutrients are the key causes of 'hidden hunger', a term used to describe any lack of nutrients other than calories.¹²

Animals turn out to be net destroyers of both iron and zinc, although the story with iron is more complicated because iron from eating animals is easier for humans to ingest, so it is worth more per gram. Even taking this into account, animals reduce our access to both these minerals. In the case of iron, animals eat more than ten times in human-edible crops what they return in meat and dairy, and even if you apply a conservative factor of four for the increased bioavailability of iron from meat compared to from plants, they decrease our supply. Meanwhile, less than one fifth of the zinc that animals take from human-edible crops comes back to us in meat and dairy.

Vitamin A is a bit different. It is one of the very few human-essential nutrients that animals create more of than they consume from human-edible crops. So in the days before it could be manufactured and routinely added to foods, the need for it could have provided a legitimate argument for more poultry and dairy in the diet. However, the advent of fortification has changed things a great deal. Vitamin A is easy and cheap to add to oils and even flour, and fortification is routine in many countries, including the UK and USA. Interestingly, China would be one of the few countries to have a net surplus even without fortification or meat and dairy, thanks to its sweet potato supply. If you are concerned about vitamin A in your

own diet, just 100 grams of this delicious vegetable gives you an amazing 709 micrograms of the stuff (compared to a recommended daily intake of 700–900 micrograms). And because they travel well on boats, sweet potatoes make a great part of a sustainable diet wherever you live. Although not as spectacular, carrots, olives and most leafy green vegetables are also very good.¹³ Finally, if none of these solutions do it for you, popping a pill is a simple and cheap last resort.

As a general rule, animal products are not a twenty-first century solution to micro-nutrient concerns, except perhaps in parts of the world that both lie outside the global food economy and are without access to proper health care. For these areas, it is still true to say that in the absence of access to a varied diet or supplements and fortification, a bit of meat can be a simple way of catching up on a variety of essential micro-nutrients. However, those circumstances will not on the whole apply to those who have access to this book.

How much of our antibiotics are given to animals?

An estimated two thirds of all antibiotics,¹⁴ 63,151 tonnes per year in fact,¹⁵ are gobbled up by animals – and some of that even makes it back to us through meat and milk.

One of the most powerful arguments for the benefits of modern technology is the increase in health and life expectancy that most of us can enjoy. The collapse of antibiotics would send a lot of that down the plug hole. And it looks close. The race between increasing resistance and the development of next-generation alternatives looks like it is going the wrong way with extremely nasty and perhaps imminent consequences. (This feels especially real for me because without them over the past five years, I might well have died, in a very unpleasant way too, both my parents would have died for sure, and there is a very good chance my daughter would have had her leg chopped off or worse.) If you find yourself in serious

need of an antibiotic, the idea of a world without them turns from a distant concept into a vivid nightmare.

Animals are given antibiotics mainly to stimulate growth and prevent rather than cure disease. This quantity used worldwide is going up fast, as diets in developing countries are changing in the wrong direction and farming practices are intensifying. The result is that animals are developing resistant strains and passing those bugs onto us. We can't blame it all on the farmers though, because much of human consumption of antibiotics is also needless.

What can I do and what can be done?

The World Health Organization offers basic advice for all.¹⁶ Here are some key points, plus my own comment on diet.

- Don't take antibiotics unless you need them, and when you do, follow the instructions.
- Cut down on meat and dairy that comes from farms that routinely use antibiotics for prevention rather than cure (and it is fairly safe to assume the worst unless you know otherwise). The 'organic' criteria include restrictions on antibiotic use.¹⁷
- Have good hygiene and keep vaccinations up to date to prevent infection in the first place.
- Farmers should not use them for growth stimulation or disease prevention, and should use vaccinations and good farm hygiene to prevent disease.

Do factory farms make pandemics more likely?

Yes. It looks very likely that today's farming practices facilitated COVID-19.

I write this as coronavirus disease (COVID-19), the latest disease to jump from animals to humans, still holds the world in fear. There have been several pandemics over the centuries caused by diseases jumping to humans from other species, most notably the Ebola virus and the human immunodeficiency

virus (HIV), as well as 15 influenzas over 500 years which came from birds. And the frequency has been going up. COVID-19 shows some but not all of the qualities of a disease capable of inflicting a full-scale disaster so it looks as if on this occasion only a small proportion of humanity will have been wiped out. It seems to be very contagious, even before the symptoms emerge, but so far, at least, it is far less vicious than, for example, the Ebola virus or the SARS virus of 2004. So you could say we have got off lightly this time and should think of it as a wake-up call.

As I write this, many people, including me, are trying to work out whether this could be the moment that humanity starts the major re-wiring project that we so badly need, but for the moment, within this food chapter, let's just ask: What has our diet and our farming system got to do with it all?

We don't yet know all the details of how COVID-19 came about, but there are some clear factors that increase our risk from pandemics.

First of all, animals crammed together in huge numbers have a capacity to rapidly cause a virus to mutate into a more dangerous form. This is a feature of factory farming, especially but not exclusively for chickens, where the numbers of animals crammed together are so high.¹⁸ The close cloning of a species that takes place in industrial farming in order to improve the quality and yield of the meat further facilitates the spread of viruses between animals and the ease of virus mutation. A further outcome of efficient factory farming has been the emergence of wild-animal farming in China, as small farmers have been pushed out of conventional meat markets. In the case of COVID-19, as I write, it looks likely that the origin may have been bats and the jump to humans came via the intermediate stage of another farmed mammal.¹⁹

So what is the solution? Less meat in our diet, more care over how it is reared. More space between animals. Less tight cloning between species. Better regulated meat markets

around the world. Less trade in endangered species for ‘homeopathic’ medicine.

How much deforestation do soya beans cause?

Don’t blame the soya bean! The problem comes when they are eaten by cows and sheep.

Gram for gram, a soya bean has more of almost every human essential nutrient than beef or lamb. But when you feed one to a cow or a sheep, you only get about one tenth of the weight back in meat. It’s a disaster for human nutrition. The bad reputation that soya beans get for causing trees to get chopped down is misplaced.

The second myth about soya beans is that they don’t taste good. They do, either as milk, tofu or simply as the beans.

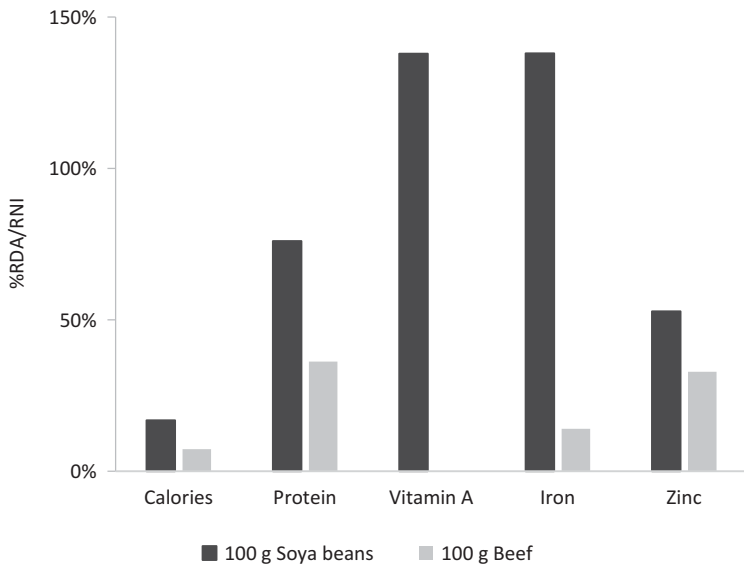


Figure 1.4 The caloric, protein and micro-nutrient content of 100 grams of soya beans and 100 grams of beef, in terms of percentage of Recommended Dietary Allowance (RDA) and Reference Nutrient Intakes (RNI).

What's the carbon footprint of agriculture?

At 23% of the global total, food and land-related emissions are far too important to ignore.²⁰

Most people who care deeply about the climate emergency seem to get so exhausted trying to make sure we leave the fossil fuel in the ground that they don't have much energy left to look at food and land. It is understandable, but unsatisfactory, since food and land emissions are enough on their own to see us in climate trouble. They are the forgotten poor relation in the climate change debate.

In rough numbers, humankind's greenhouse gas footprint is 50 billion tonnes of carbon dioxide equivalent (CO₂e) per year, of which about 23% comes from food and land. Agriculture's single biggest source of CO₂ is deforestation, most of which can

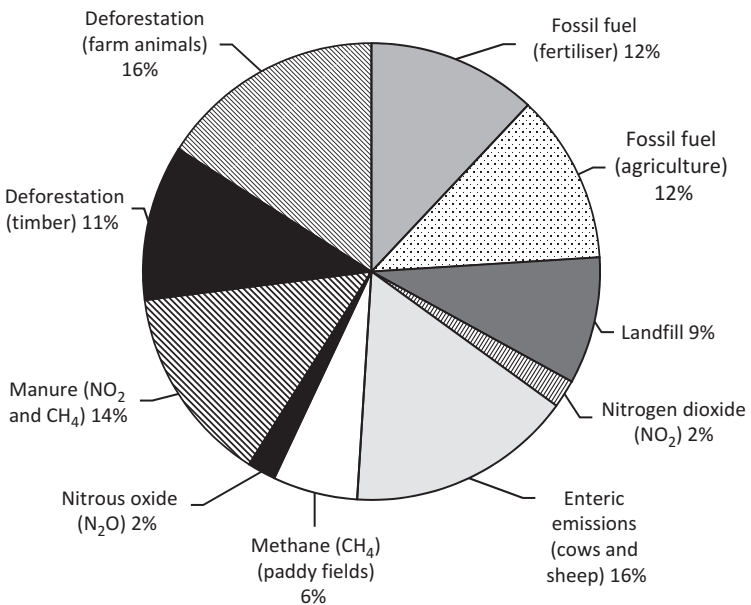


Figure 1.5 Breakdown of food and agriculture's 23% contribution to humankind's greenhouse gas (GHG) footprint.

be tracked to meat production, but some to timber. When the trees are cut down, we lose not only the carbon stored in the wood, but even more importantly, over a period of a few years we lose most of the carbon stored in the soil as well. Fossil fuels used in the manufacture of fertiliser, powering agricultural equipment and in transport, are a relatively minor player. But on top of the CO₂, most of the world's methane can be put down to food and land, with the greatest sources being enteric emissions (that's cows, sheep and goats chewing the cud and burping), flooded paddy fields, and rotting food matter in poorly managed landfill sites. About two thirds of all nitrous oxide is also attributable to food.

What are the carbon footprints of different foods?

The following charts have been adapted from a huge meta-analysis of the environmental impacts of over 38,000 farms.²¹

The average person needs about 50 grams of protein a day for a healthy diet and the chart shows the carbon footprint of some of the different ways of getting it. Beef and lamb have the highest impact because they ruminant (burp up methane). Beef also often has considerable deforestation associated with it, when land is cleared for feed production and grazing. Dairy products are lower impact than meats because it is more 'efficient' to keep the animal alive as a protein producer than to kill it. Of the meats, chickens are more efficient than the larger animals. They grow quickly, especially if you pack them full of antibiotics, and they don't waste much energy walking around much or keeping warm if you keep them in a crowded indoor space (see box). Note the land-use change resulting from animal feed for most meat and dairy. Note also how dramatically lower impact all the plant-based protein sources are.

All the staple carbohydrates are relatively low carbon, but rice comes out worst (see next question). Maize comes out best because corn is a particularly efficient photosynthesiser. Note

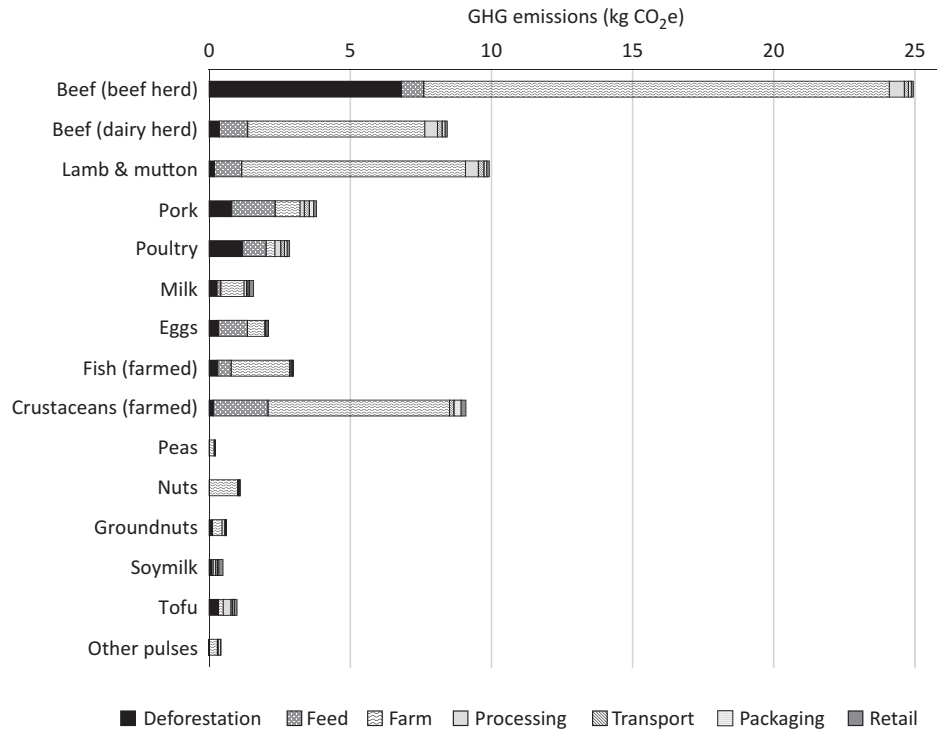


Figure 1.6 The GHG footprint of common protein sources per 50 grams of protein, broken down by supply chain stage.

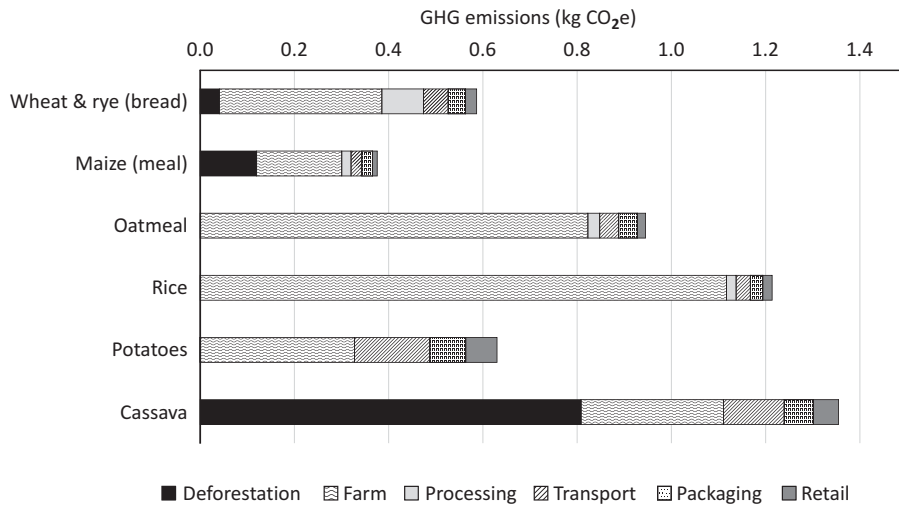


Figure 1.7 GHG emissions per 1,000 kcal from staple carbohydrates, broken down by supply chain stage.

the deforestation associated with cassava, much maize production and some wheat.

Is chicken the best meat?

Judging from its emissions, chicken might be thought of as the most 'environmentally friendly' meat, perhaps the best option for the caring omnivore. However, despite chicken's relatively glowing carbon credentials, poultry farming poses a whole host of other problems for both the local and global environment.

Broiler chickens (those that are raised specifically for their meat) have been bred to grow very quickly, and this leads to many welfare concerns including skeletal deformations and congenital heart defects. Stuffing as many birds as possible into a barn encourages the spread of disease, both viral and bacterial. Using plenty of antibiotics helps with the latter in the short term but contributes to increasing microbial resistance to drugs. So one of the trade-offs with this farming system is between the antibiotic resistance you encourage by using antibiotics against disease mutations versus the risk of human pandemics if you don't. Nasty for humans either way. Clearly the most ethical way to raise chickens is free-range, and a myriad of environmental impacts have emerged in recent years as demand and legislation for free-range birds has increased.

Most notably among these impacts, pollution. Chicken poo is full of nutrients, particularly phosphates. Raising hundreds or thousands of these birds outdoors results in a lot of poo, which can be washed off farmyards and pastures after rain and floods. The nutrients enrich local waterways and water supplies, triggering harmful algal blooms. Furthermore, chickens are often fed on soya, sourced from abroad, and associated with deforestation and other harmful farming practices.²²

Should I go veggie or vegan?

Great idea! Lower consumption of meat and dairy is essential for the food supply, climate and biodiversity. But, none of us needs to go quite all the way unless we want to.

Some of the world's meat and dairy still comes from grass-fed animals. And some of that grass is grown on land that is not fit for crops. While it is true that some of that space might be better used for other environmental purposes, such as carbon capture and biodiversity, we should not dismiss the role that animals can play in turning nutrition that we can't digest into food that we can. Animals can add to the variety and health of our diets but there is an undeniable need for a reduction to perhaps half today's global average meat and dairy consumption. It means we will need to see much deeper than 50% cuts in meat consumption in most richer countries. It means reversing the current global trend towards more meat, which the United Nations Food and Agricultural Organization predicts will lead to a 23% increase in meat and dairy eaten per person by 2050.

Because food conversion rates are higher for dairy than for meat, while a move towards less meat and dairy is the most helpful dietary change, swapping meat for dairy is also helpful.

The first piece of really good news is that most meat eaters could make both these transitions in ways that enhance not only their health but also the variety in their diets. Just a personal view, but in a taste and texture contest, surely veggie haggis slaughters the traditional version? A second piece of good news is that, as I write, veganism is gathering momentum in many rich countries, providing perfect role models for the world's aspiring middle class.

Cutting consumption of meat and dairy also turns out to be the best place to start when it comes to cutting the carbon in our food (I'm using carbon as a shorthand for greenhouse gases). I've written about food greenhouse gas emissions extensively before, not least in my first book, *How Bad Are Bananas?*

The Carbon Footprint of Everything, which I now unashamedly plug along with a couple of academic papers on carbon and diet.²³ To summarise all of that, the top priority is to cut down on the ruminant animals: cows and sheep.

There is no need for extremism here, just moderation and a broadening of choice. If everyone who has that choice asks ‘Shall we have meat, pulses, beans or eggs tonight?’ in the same open-minded way that they might ask ‘Shall we have pasta, potatoes or rice?’, that shift alone could generate enough space in the whole food system to feed the 2050 population, while allowing more land to be devoted to biodiversity and, at the same time, if we wanted, liberating a bit more land for biofuel too (see page 49 and *Are biofuels bonkers?* on page 88).

If and when you do eat meat, as we have seen, some types are more impactful than others, but all have a bigger climate impact than their plant-based alternatives. We see a hierarchy of carbon footprints with pulses, grains and soya beans as the clear low carbon winners, dairy and poultry products as runners up, and red meats in worst place.

What can shops do about meat and dairy habits?

Make alternatives to meat and dairy delicious and tempting.

There has been a widespread myth that supermarkets are forced to sell what the customer wants to buy, and therefore have no control over what they put on the shelves. This is clearly nonsense. Supermarkets are highly practiced at steering you towards the product with the highest profit margin. For over a decade now I’ve been working with one food retailer that completely understands the influence they can have. They are not a company that sets out to be radical and they certainly experience no less commercial pressure than the larger supermarkets with whom they compete. But they understand that it is possible sometimes to make the most sustainable foods look

the most attractive to buy. A lot of my work for them has been about encouraging them to do this more often. Sometimes they remind me of commercial realities that they think I may have forgotten. But every now and then we find a new area of improvement; pushing seasonal vegetables, making the meat alternatives look delicious, a Christmas brochure full of vegetarian options, a new range of local seasonal flowers to replace less sustainable imports, advice on the use of left-overs . . . There are still big areas I'd like to see more progress on, but overall the change I have seen has been significant and genuine.

The single biggest area for any supermarket to work on is the ratio of meat and dairy to alternatives in their sales mix. As we have seen, even within meat and dairy there is a hierarchy of impacts, with beef sitting clearly at the high impact end (and cheese not far behind).

What can restaurants do?

If a customer chooses a vegetarian or vegan dish, they do actually expect to enjoy it just as much as if they had chosen meat. Sounds too obvious to be worth writing down, but clearly this message has not yet been universally grasped. Restaurants should increase the range of vegetarian/vegan dishes and make them at least as delicious, tempting and inspiring as anything else they sell.

What can farmers and governments do?

There are many factors to take into account. Alongside nutritional output, biodiversity and climate change there are important questions including animal husbandry, livelihoods, communities and traditions. Where I live there are even arguments about sheep as tourist attractions. These perspectives need to be considered simultaneously with open-mindedness, transparency, respect for the evidence and respect for the people involved.

Some things are clear from the science. The world needs fewer farmed animals and much less crop-based animal feed. We need to be more careful with fertilisers and antibiotics. Some land is unfit for anything other than biodiversity or grazing, and when working out what to do with it, we should bear in mind that over-grazing can trash biodiversity as well as soil carbon. It also looks clear that the right animals grazing in the right way can enrich the soil, including its carbon storage.

It is also clear that doing the right thing requires more work, and therefore jobs, than is required to simply maximise output in the short term. It takes care, skill and effort to look after land properly. So, a sustainable food and land system offers a huge net livelihood opportunity. This must surely be good news for farmers and their communities.

Even though there is a place for farmers to try to improve sustainability where they can whatever support they get, the right incentives and subsidies will clearly make this a lot easier. Farmers, scientists and governments need to work together sensibly to make this happen.

How could one crop save us over half a billion tonnes CO₂e?

Over 1% of the world's total greenhouse gas footprint could be saved by simple improvements to the way rice is usually grown.

This is a big untold story. It has nothing to do with the fossil fuel used by tractors, lorries, boats or any other parts of the supply chain. Specifically, what is needed is more judicious use of fertiliser and not flooding paddy fields.²⁴ Paddy field methane is about 6% of all greenhouse gas emissions from the food supply chain. I've seen photos of rivers in China that are bright green from so much excess fertiliser; the yield is probably actually suffering from over application. Sounds simple, but until the issue gets more traction it is hard to make

progress. I have been on the lookout for a sustainable rice supplier for Booths, the UK supermarket chain, for a few years now. It is proving weirdly difficult. The Sustainable Rice Consortium looked promising, but it turns out that while they would like Booths to fund them, they can't actually point to any sustainable production anywhere. For the moment, rice is the most greenhouse gas intensive of all the staple carbohydrates, by more than a factor of two.

A final note for perspective: despite all the scope for improvement, a vegetarian rice dish still counts as a relatively sustainable meal.

What can I do?

For the moment, buy rice a bit less often than you might have, until such time as you find a more sustainable supply. When you find such a supply, let me know at Mike@TheresNoPlanetB.net. Tell your friends and your shops. Make sure people you talk to understand the issue.

What can shops do?

Find a sustainable rice source and market it as such.

What can farmers do?

Use fertiliser sparingly – which might save money too. Don't flood the paddy field. Then market your sustainability credentials to boost sales.

Is local food best?

Only sometimes. Transport is usually a small component of the carbon footprint of foods.

Travel is usually just a small part of the carbon footprint of food. In my latest study for Booths, transport was responsible for just 6% of the carbon footprint of all goods at the check-out.²⁵ The big greenhouse gas deal is in the farming (see What's the carbon footprint of agriculture? on page 25).

Food transport only really becomes a big problem when things get put on an aeroplane. UK examples of this can include grapes and berries from California, fresh tuna from the Indian Ocean, baby vegetables from Africa and, perhaps worst of all, asparagus all the way from Peru. (You can't eat flowers, but many of them also travel on planes so the same rule applies.)

By contrast, putting food on a boat, even from the other side of the world, can enable a relatively sustainable food supply. What turns out to be a fairly small transport energy demand comes in return for an important flow of nutrients from places with plenty of sun and fertile land to highly populated places that are unable to meet their own food needs. Nor are a few hundred road miles a disaster, although the fewer the better, especially when it comes to heavy stuff like beer. So, a pint from your local brewery probably beats any other alternative, unless, as is sometimes the case in the UK, it comes to you via a warehouse at the other end of the country. Local tomatoes grown in an energy-intensive hot house in winter could be many times less sustainable than the shipped alternative from a sunnier part of the world. (And in the case of flowers, hot housing them out of season is no better than putting them on a plane.)

There is no place for air-freighted food in the twenty-first century.

To summarise, come the sustainable world, there simply won't be any air-freighted food. In the meantime, you can help by avoiding it where you can and having done that, you can largely relax about food miles and perhaps just use that argument as one more reason to enjoy a local pint in preference to one from thousands of miles away.

To tell whether something has been on an aeroplane, check the country of origin and ask yourself whether it has the longevity to survive the journey by ship, train or lorry. Bananas, apples and oranges usually can survive, whereas strawberries, grapes and asparagus generally can't. If something is locally grown but out of season it will have to have

been hot-housed, which can be just as bad as flying. A UK example would be Scottish strawberries in January.

(A quick plug is irresistible here: you can find much more on this in my first book, *How Bad Are Bananas?*)

Sadly, if you just look at things from a local and short-term point of view, crop monocultures and intensive cattle farming, dependent on fertiliser, pesticides and bucket loads of antibiotics (see page 21) can be fine, and even deliver the most profitable yields. So, biodiversity management gives us yet another example, as if it were needed, of the inadequacy of the free market to deal with Anthropocene challenges.

Well done for reading so much bad news, rather than turning away. Having faced some difficult realities it is now high time for us to look at what can be done with our food and land to sort things out.

Where does fish fit in?

The world catches or farms 80 million tonnes of fish per year. That is about 12 kg per person per year or 30 grams per person per day. This could just about be sustainable, with care.

The fishing industry ranges from village canoes to huge trawlers out at sea, manned by slaves and plundering the seas in whatever way is most profitable, refuelling and transferring their catch at sea to avoid all forms of governance.²⁶ Roughly half of all production is industrialised trawling and farming, while the other half is small-scale hand fishing. There is about 10 million tonnes of by-catch per year (4 grams per person per day) – that's the stuff that is caught by mistake and thrown back, probably dead, into the sea. Small fisheries currently provide an important source of essential nutrients (zinc, iron and calcium as well as protein²⁷) in many poorer parts of the world. Access to this supply depends firstly upon the small-scale fisheries not being over-run by industrial trawling, and also upon the local fish not entering the global market, at

which point the world's poor are unable to afford it. Thirdly, climate change is likely to alter migration patterns and habitat areas of some fish,²⁸ with serious consequences for some communities.

Fish stocks globally are under huge pressure. The Marine Stewardship Council (MSC) estimates that 90% of world fish stocks are currently fully or over exploited.²⁹ So, for all fish's relatively low carbon credentials, there is no scope for increasing total supply and perhaps the world should be cutting consumption. Even if not, those of us in richer parts of the world need to think carefully about who might not get to eat fish so that we can.

Is farming the solution? Sadly, farmed fish are just farmed animals that swim, and the moment you get into this you incur all the problems that are associated with most of the world's animal farming; fish feed is no more nutritionally efficient than giving human-edible food to animals; farmed fish are often plied with antibiotics and polluting chemicals; the overcrowding can be similar to that found in factory farms. While a sustainably caught wild fish might arguably be thought of as a sustainable nutritional food bonus, farmed fish cannot.

The MSC certifies sustainable fish brands but their credibility may not be as high as we could hope for. Here's the catch (haha). It turns out to be a 'for profit' organisation that makes, for example, £10 million from certifying a big fishery (see page 203) for my guidelines on how to work out who can be trusted). As I write this, the MSC looks to be on the verge of certifying fisheries that do pole and line fishing one day, and then use the same boats to trawl indiscriminately the next.³⁰

When is a seabass not a seabass?

When it is a Patagonian toothfish – renamed into a Chilean Seabass for promotional purposes.

The price and popularity of fish seems to have little to do with taste or nutritional content, and everything to do with

marketing. To give just one example, Patagonian toothfish was undesirable until a Californian fish merchant marketed it as the new-found delicacy of Chilean seabass in the late 1970s,³¹ pushing the price to over £60/\$85 per kilo. It isn't even a seabass! Sadly, the result of all the popularity is that stocks of this once-abundant fish, found in the deep (by which I mean anything from 300 m to over 3.5 km down) Southern Ocean, and able to grow to over 2 m in length and 100 kg in weight, are now threateningly low. And it takes 45 years to replace a 45-year-old fish. Over 80% of Chilean seabass, once Patagonian toothfish, is thought to come to us through unregulated fishing.

Another example of the many fish that have been renamed to make them sound more familiar to un-knowing consumers is the changing of the weird 'eitch' to the delicious 'Torbay sole'. Similarly, the gross-sounding 'slimehead' has become the exotic 'orange roughy'.

It is good that we can be persuaded to like anything that is available, but not if the ensuing fad leads to stock decimation.

How can we sustain our fish?

What can I do?

Here are six guidelines that I think seem sensible for non-vegetarians.

- **Treat fish as a treat.** The global average of 30 grams per person per day would only be sustainable with major improvements to existing fishing practices and transparency. Even then, most of us would still have to eat less in order to allow those who have to rely on it for their main nutrition to have what they need. So 30 grams per day would be two small fish meals per week or one larger one.
- **Find a fish monger who can talk to you convincingly** about where their fish comes from and how they know that slavery, by-catch and over-fishing are all minimised, and secondly can advise you on the sustainable options of the

day. Specifically, the Sustainable Food Trust³² suggests questions along the following lines:

- * ‘Can you suggest a fish for me to buy today? I want to try something different, which is sustainably and ethically sourced!’
 - * ‘Can you tell me about how and where it is farmed or caught?’
 - * ‘Why do you source from this particular farm or merchant?’
 - * ‘What are the environmental and ethical issues to consider with this particular type of fish?’
 - * ‘How do the seasons affect what fish I should be eating right now?’
- **Be open to different species**, including obscure, unfamous varieties that you may never have heard of. These will probably also make your diet more interesting. If you can, buy from someone who can tell you how best to cook it.
 - **Don’t let price or marketing count as evidence of quality**, because it probably isn’t. But equally, be prepared to pay more for your ethical and sustainable treat.
 - **Take note of sustainability labels but treat them with caution.** For example, ‘dolphin friendly’ is a red herring on any tuna of the skipjack variety, as it does not, and has never, swum alongside dolphins. The ‘Pole and Line’ label is probably still worth something. Sadly, there are no effective labels to let you know how much slavery you will be supporting.
 - The MCS (and NOT to be confused with the MSC) produces a valuable and accessible **Good Fish Guide**.³³

What can shops do?

- Understand your supply chains. Source sustainably and let your customers know what you are doing. Take heed of sustainability guidelines from the MSC but go deeper. Avoid the naughtier brands, and don’t be scared to boycott in the light of new findings, even if they are household names.

- Vary your fish stock in line with sustainable availability, and educate your customers towards a more interesting and wide-ranging fish taste. Let them know why you are doing this.
- Avoid air freight. If you do need fish from the other side of the world, properly frozen and put on a boat is the better option by far.
- Finally, help your customers to understand that fish is a valuable and limited resource. Make sure your sales people can give good answers to the customer questions listed above.

What can governments do?

- Ensure your own waters are sustainably fished. Easier said than done if there are fish pirates and boundary disputes, but this is the challenge.
- If fish is an important source of nutrition for your people, don't let it enter a global market until your own population can afford to buy at those prices.
- Police the industry, rooting out the slave trade as best you can.

What can fishermen do?

Is this too obvious to mention?

- Don't over-fish.
- Make sure everything you catch is eaten.
- Sell locally where you can.
- Don't run a slave ship.
- Do stick to the rules.

Now we move on to look at waste, the second biggest issue that jumps out of the global calorie and protein flow maps.

What food is wasted, where and how?

Out of 1,320 kcal wasted per person per day, 48% is cereals. That's enough calories to feed everyone in China and America. Nearly two thirds of all losses occur in harvest or just afterwards, in storage.

Table 1.1 The proportions of all calories wasted, by region, food type and stage in the journey from field to mouth. (Due to rounding errors, totals do not always equal the sum of the components.)

Regions / Waste stage	Harvest	Post-harvest	Processing	Distribution	Consumption	Total
Africa	4%	4%	1%	1%	<1%	10%
Americas	9%	2%	1%	1%	9%	22%
Asia	17%	21%	3%	7%	5%	53%
Europe	4%	3%	1%	1%	6%	15%
Global	34%	30%	5%	10%	20%	100%
Food groups / Waste stage	Harvest	Post-harvest	Processing	Distribution	Consumption	Total
Cereals	15%	17%	<1%	3%	13%	48%
Roots and tubers	3%	4%	<1%	1%	1%	9%
Oilseeds and pulses	13%	8%	<1%	1%	1%	23%
Fruits and vegetables	3%	1%	<1%	2%	2%	9%
Meat	<1%	<1%	2%	2%	2%	5%
Fish and seafood	<1%	<1%	1%	1%	<1%	2%
Milk	<1%	<1%	2%	1%	1%	4%
All foods	34%	30%	5%	10%	20%	100%

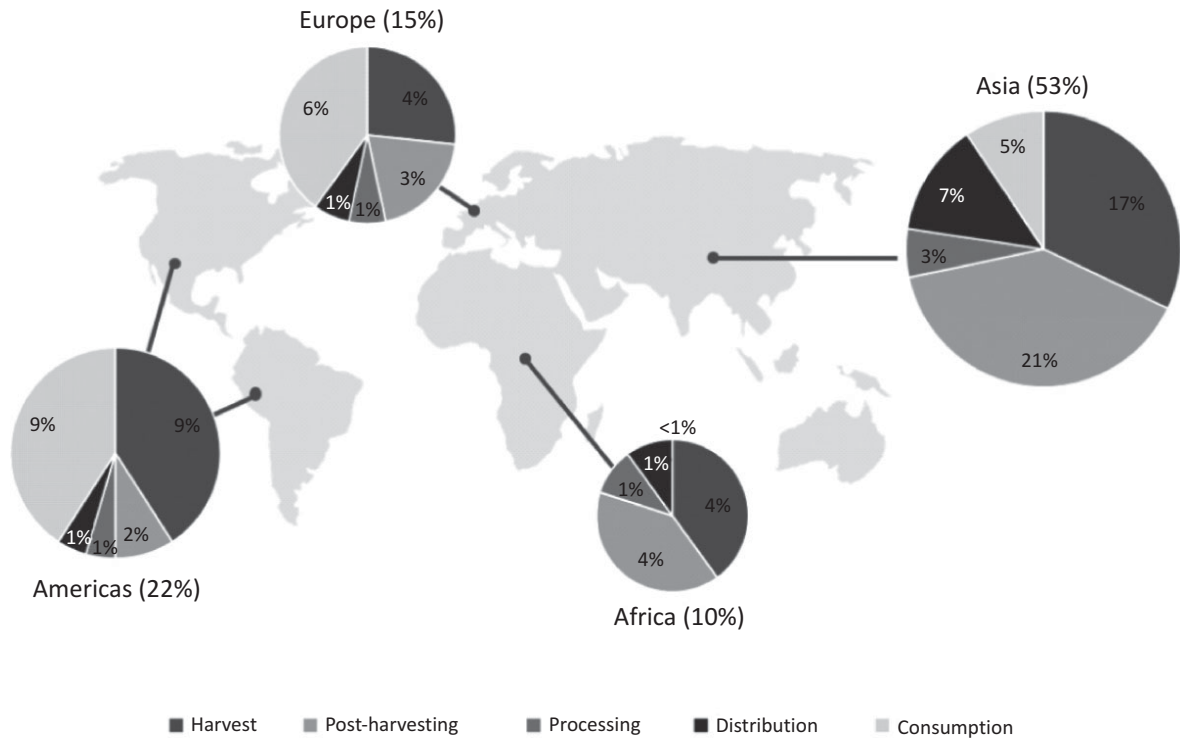


Figure 1.8 Where and how is food wasted (Oceania not included, but accounts for <1%)?

After dietary change away from eating too much meat and dairy, cutting waste is probably the next most important way to ensure there is enough nutrition to go round.

It is tempting to rage about waste everywhere we see it. This is fine as far as it goes but if we are serious about making improvements, we'd better have a closer look at how much is generated and where. Only then can we begin to prioritise. Waste stats are often quoted in tonnes, which doesn't help us because it gives a kilo of watermelon the same significance as a kilo of discarded beef or cheese. So I am going to talk about waste in terms of calories lost (protein matters a lot too, but the story turns out to be quite similar³⁴).

Consumers account for 20% of all food waste, of which three quarters comes from the one quarter of the world's population living in Europe and the Americas. Even more seriously, but

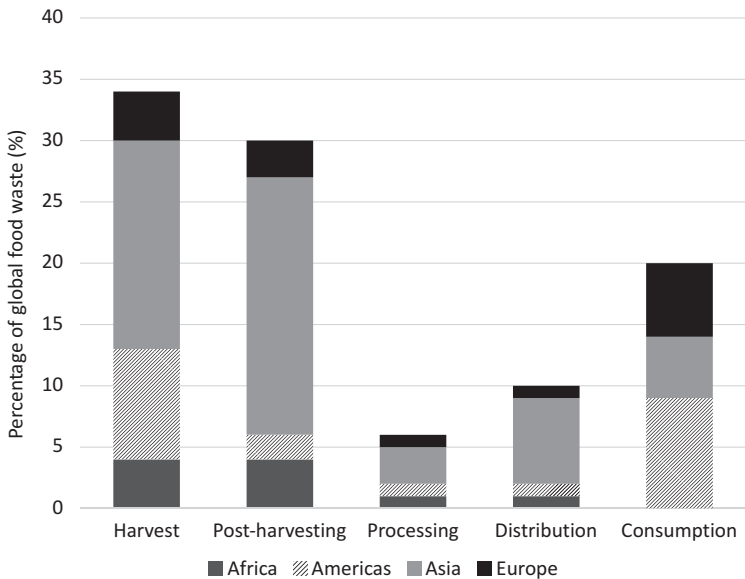


Figure 1.9 Global food waste by region and stgsge in the process.

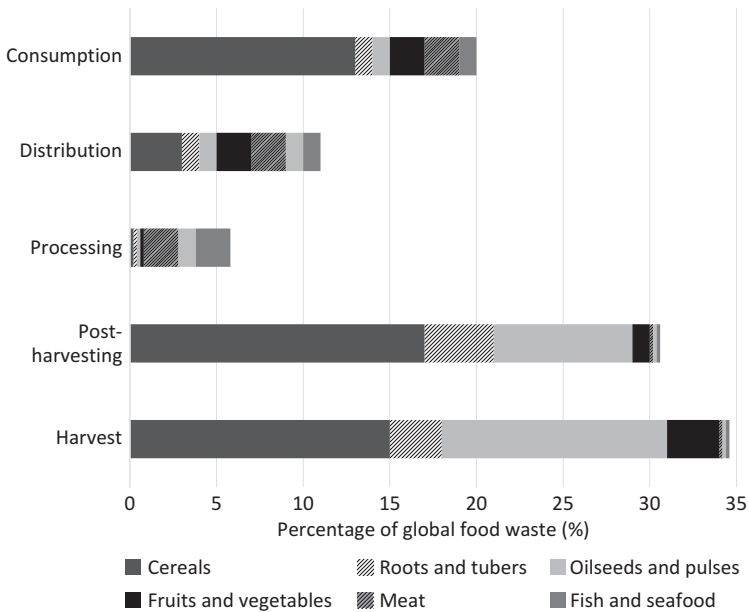


Figure 1.10 Global food waste by food type and stage in the process. Cereals account for 48% of all calories lost. Meat, fish and dairy together make up 9%.

less visibly, 34% of all wasted calories occur at the harvesting stage and 30% during storage. Over half of all waste takes place in Asia, where the biggest losses are in post-harvest storage (21% of all the world's waste), harvesting (17%) and distribution (7%).

Every region has different waste issues. In Europe, household and catering wastage dominates. In the Americas, levels of consumer waste are similar to Europe, but harvest losses are higher. In Asia and Africa, most of the losses take place during harvest and subsequent storage rather than at the household level; the problems here lie in the food industries rather than with careless consumers.

In terms of which foods get wasted, cereals account for 48% of all calories lost, while meat, fish and dairy together account for just 9%.

How can we cut the world's waste?

Cutting waste by half would add 20% to the world food supply.

In developing countries this mainly means more efficient harvesting and storage; in developed countries and among the world's rich, it is more to do with eating everything we buy. Most of what is required boils down to some relatively simple facilities in poorer countries and some cultural change in richer countries.

What can I do?

Eat what you buy. This sounds too obvious to mention but the developed world is spectacularly bad at it. This action is about looking in the fridge before deciding what to buy or what to have for dinner. Don't 'buy one-get one free' unless you know you will eat it. Learn to do great things with left-overs. The elimination of household and catering waste in just Europe and the Americas alone would add 10% to the world food supply.

What can restaurants do?

Help customers have only what they will eat on their plate. Options include self-service and portion size choices. And, of course, offer boxes and bags (recyclable ones) for left-overs.

How can shops help us cut waste?

The biggest thing a shop can do to help is to encourage its customers to cut waste. To do this also means being a good role model.

Supermarkets need to help people to buy only what they will eat. To some managers, this sounds like commercial suicide,

but there is a lot of customer trust to be gained, as well as increased ability to live with yourself. Apart from skilful stock management and discounting, here are some of the things I have seen successfully tried at Booths, my semi-local supermarket chain:

- Buy one-get one free *next time*.
- Selling fruit and veg loose so people can get exactly the amount they require.
- Train the fresh counter staff to help single people buy single portions.
- Sell a good range of products for preserving left-overs.
- Promote menus for left-overs – especially after Christmas (or Thanksgiving).

Cutting their own waste further of course sets a good example, and customers are rightly upset when shops throw food away rather than giving it away.

As I write this, I am sharing the office with an intern, Sam, who does his local supermarket a favour most weeks, easing their conscience by raiding their bins for food. He periodically comes to work with a backpack full of random items that his own student network can't deal with. Between us all we do our best to make sure it all goes in to human mouths somehow. The office feels like a food bank at times, except that instead of providing for the genuinely needy, it often turns out to be more about middle-aged people like me eating more cake than is good for them. The difficulty for the supermarket is that by the time a product is so close to its end of life that it can't be sold, even for a tenth of its original price, it is very hard to give it away either. Sam brings in only low risk foods and they look fine too, so we all feel safe, but the supermarket has to be more careful still. The result is that there is not time to distribute it out via real food banks. A way round this might be to rapidly freeze stuff just before the use-by date, but for that to work the supermarket needs to care enough that it will stand both the extra cost and the extra hassle, compared to throwing it in the bin.

Why don't supermarkets care more about their waste?

They already care a great deal because it is so expensive for them. A well-run supermarket will lose less than 0.5% of its food, whereas the average European household wastes nearly a quarter of food that it buys.

Some of the most headline-hitting sources of waste actually turn out to be some of the least significant. Retailers in Europe and America, for example, are already highly incentivised not to throw away food because it is so expensive. For the same reasons, manufacturing waste levels are also fairly low. So while it is right that supermarkets shouldn't throw stuff in the bin that they could give to food banks, and while it is important that they are seen to be role models, we also need to recognise that this is a small part of the total waste problem. Finally, for perspective, remember that waste in itself is a smaller issue than the rising level of meat and dairy in the global diet.

When food can't be sold or eaten, what should be done with it?

Feed all human food to humans whenever you can. Avoid landfill. Be careful with garden compost. Don't get too excited about any other options.

Having done everything possible to get all its food to the check-out, a supermarket is still bound to end up with some that it can't sell. The chart below is based on some recent research we did at Lancaster University to help UK retailers understand their options.³⁵ It describes how good each disposal pathway is for mitigating the waste from a greenhouse gas perspective: 100% indicates that the problem has been completely solved, 0% represents not having mitigated the problem at all, and negative numbers indicate disposal pathways that actually make things worse by creating yet more emissions.

Emissions mitigation (%)	Bread	Cheese	Fruit and veg	Fish	Meat	Average food
Donated	100%	100%	100%	100%	100%	100%
Fed to animals	24%	7%	1%	41%	5%	6%
Anaerobic digestion	20%	4%	5%	19%	4%	6%
Composted	3%	1%	-1%	5%	1%	1%
Incinerated	11%	2%	-2%	1%	1%	1%
Landfill (gas captured for electricity) ³⁶	-44%	-7%	-12%	-26%	-7%	-10%
Landfill (gas captured but flared)	-61%	-10%	-16%	-36%	10%	-14%
Landfill (no gas capture)	-227%	-37%	-61%	-136%	-36%	-53%

Figure 1.11 Savings in greenhouse gas footprint of foods resulting from different disposal options. All solutions are rubbish, except for donating it for human consumption.

The first thing to see is that finding a way of donating the food so that it is eaten by humans is the perfect solution, and the only one that should be thought of as satisfactory. You incur a little bit of extra transport, getting it to a food bank, say, but the impact of that turns out to be insignificant.

All the landfill options make things worse by generating methane, a very powerful greenhouse gas that is impossible to completely capture. Some landfill sites leak more methane than others.

In the middle of the range are a bunch of solutions that sound good but whose success is largely limited to not making things worse. Bread and fish typically have low carbon footprints compared to their calorific content, and this means there is a bit more benefit in feeding them to animals, or burning or anaerobically digesting them to generate electricity.

What can I do?

Households can take away many of the same messages. Give your food to a friend or neighbour if you can't get through it yourself. Whether the stuff you throw in the bin goes to landfill or not will probably depend on your local authority. Where I live the food in general waste 'grey bins' ends up being turned into fuel for incinerators.

One note of caution is that your garden compost has to be turned over often enough that it rots aerobically (i.e. with access to oxygen), rather than anaerobically – which is roughly like having the worst kind of landfill site in your own back garden belching out methane.

After animals and waste, third on the list of big food issues that leap out of the global food nutrient flow maps comes biofuel.

How much food goes to biofuel?

The answer is 810 kcal per person per day. That's the same as a 10" margarita pizza every day for everyone in the world.³⁷ It creates enough fuel for everyone to drive just half a mile in a traditional, oil-burning car.

After animal feed and waste, biofuel looks like the third biggest cause of loss to the human food supply. If we are being precise about it, the figure here is for all 'non-food uses' and these also include cosmetics, pharmaceuticals, paints, plastics and all sorts of stuff. But it is mainly biofuel. We will see later that biofuels are mainly bonkers (page 88). Enough wheat to provide the daily calorific requirement for one person for a day is only enough to power a small petrol car, such as my Citroen C1, for one and a half miles. If biofuel for cars became popular, it would lead to a lot of hunger. We need to watch this like crazy as we move to the low carbon world. To spell out the threat, a carbon price that is high enough to see the fossil fuel staying in the ground would mean that in a free market, wheat would often be more profitably directed to biofuel than to human mouths.

How many farmers does the world need?

More than the 1.3 billion that we have now. The good news is that the world has no shortage of people.

The number of people working on our land today is falling. But by 2050 there will be about a billion more of us of working age. As the population climbs to 9, 10 and 11 billion, keeping everyone busy could well become increasingly challenging. Yet because people cost money to employ, the free market ensures that much of our agriculture is geared to minimising the number of farmers per square mile. For all our technology, it still takes personal care and attention to grow food productively, environmentally and even beautifully – and doing this must surely be one of the most inherently positive ways that a person can spend their time on the planet. So we need top-down interventions to encourage more people to work on our land. Neoliberalism's free market, as we will see throughout the book, turns out to be unable to deliver what we need.

Governments: since the free market can't look after the land, in large part it will be up to you to get things working properly. You need to incentivise the right things and set up subsidy programmes to get a sustainable agricultural system in place.

How can new technologies help feed the world?

As we've seen, with enough societal change and waste cutting, and without adverse effects from climate change, no new technology would be needed. But if sensitively applied, it can make life considerably easier.

In other words, unless climate change severely reduces land productivity, it is not true to say that we *need* new technologies in order to get by but it is also not true to say that technology alone will solve the problem. And we will also see in a few pages' time that there can be no place for any technology that gets in the way of a shift towards a more biodiverse agricultural system. On the other hand, if the climate crisis reduces yields

or the population grows higher than the 9.7 billion predicted in 2050 then further measures become necessary.

A range of emerging technologies from genetic modification to lab meat or using solar power for irrigation are all on the cards. All of them need applying with sensitivity, without which some of the possibilities on my list conjure up nightmare images. They might even allow us to deal with a global refusal to cut meat and dairy production. The essential point to grasp about emerging technologies is that while they stand to be helpful if used in ways that are sympathetic to both people and planet, they will not in themselves create a world in which everyone has enough, or in which biodiversity is preserved or in which our essential relationship with nature is restored. However, key helpful technologies include:

- **Indoor plant farming:** There is a very unromantic reality that the most efficient way to grow food is going to be to house it in special tower blocks for plants, sometimes referred to as vertical farms, with lighting powered by solar panels and every nutritional input carefully optimised with high-tech monitoring and the latest algorithms.
- **Lab meat:** While this may be no more appealing a concept than indoor plant farming, this could offer a considerable improvement on most of today's meat industry.³⁸ Potentially tasty, efficient and humane.
- **Water technologies:** Ways of growing more with less, using green energy for irrigation and desalination. In short: food from the deserts. Graphene promises a huge advance in desalination efficiency while the solar revolution provides the power.
- **The development of rice strands that are capable of a more efficient type of photosynthesis, as deployed by maize.** (Sometimes called C4 rather than C3 photosynthesis.) The Gates Foundation is pumping £14 million into this.³⁹
- **Genetic modification:** Carefully applied and freely available, this could help with higher yields, better

nutritional content and lower greenhouse gas emissions, less water consumption and better climatic resistance.

- Waste reduction apps are emerging to connect food that needs eating quickly with people who could put it to good use.

Even simpler than new high-tech solutions is the propagation of well-established best practice such as judicious use of fertiliser and reduction in paddy field flooding.

UPDATE. Over the past 12 months I have been getting my head around factory production of both carbohydrate and protein. The reality is that this stands to be far more efficient than plant-based food.⁴⁰ Solar panels can convert roughly 20% of the sun's energy to electricity and a pilot factory in Finland claims to be able to store electrical energy as carbohydrate with 20% efficiency. Overall, that delivers carbohydrate from sunlight with an incredible 4% efficiency. This is perhaps 50 times more energy efficient than growing wheat. Similar efficiency gains look possible with protein production. If this is the case, every hectare of land devoted to solar panels for food production could enable a further 50 hectares to be used for biodiversity. To me, it isn't an immediately appealing food solution, but if it can help us to feed everyone while improving biodiversity and dealing with the climate emergency, perhaps it is worth it. Of course it puts even more pressure on resources required for solar power. And we should remember that if it is not combined with a more sensitive approach to the planet, all we will end up with is factory-created food, *alongside* a climate disaster and a biodiversity collapse.

How can we produce enough food for 9.7 billion of us in 2050?

As we have seen, the priorities are (1) to reduce human-edible food being fed to animals, (2) to cut waste, (3) to keep biofuels in check and (4) the sensitive application of new technologies.

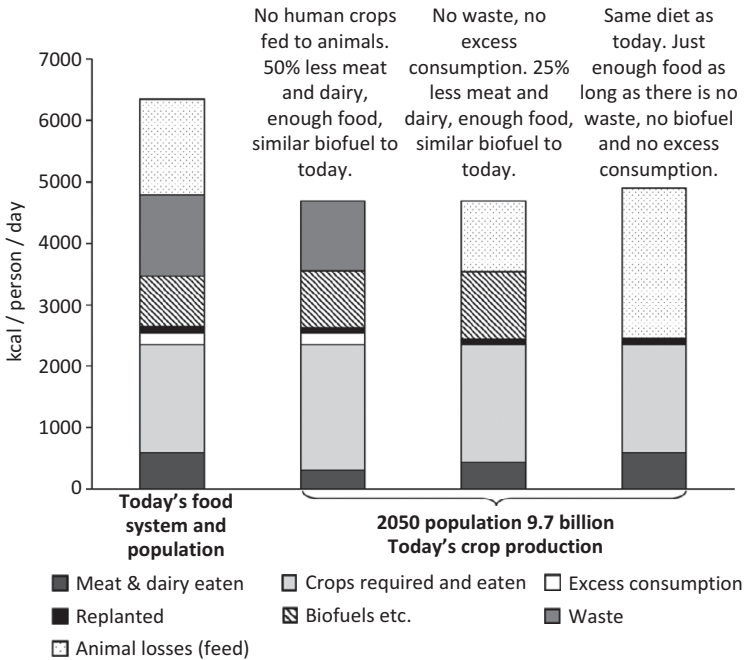


Figure 1.12 Food scenarios for 2050. In 2050 we can happily feed 9.7 billion people if we halve the waste and cut by 80% the amount of human-edible food we feed to animals. This will lead to the amount of meat and dairy per person dropping to about half today's global average. On the other hand, if meat and dairy consumption per head stays the same we will be in deficit unless there is no waste, biofuel and excess consumption.

The chart shows some scenarios to 2050, based on exactly the same crop production that we have today.⁴¹ It shows what happens when the population rises to 9.7 billion (as predicted for 2050⁴²), and how we could get by under different levels of meat and dairy consumption and waste. In each scenario, note that the biofuels wedge does not have to be used for that purpose – it can be read as a measure of spare capacity in the system to liberate land for other environmental purposes, including biodiversity and carbon sequestration.

While this chart looks at the total food supply, we should remember that even the most abundant food supplies can still be hoovered up by the rich, to deny the poor.

Why do we all need to know our food supply chains?

Supply chain knowledge is about appreciating what lies behind our food just as much as we think about what it looks like, tastes like and costs. In our minds, the history of a product needs to be part of the product itself. Although listed here as a food-related action, now we are in the Anthropocene this essential principle applies to everything we spend money on.

Getting to know your supply chains means understanding the implications for both people and planet. Which products and brands, at which times of year, and from which countries, are in tune with a low carbon and sustainable world? Which supply chains are reducing inequality? Get to know whether food has been air-freighted, hot-housed or grown in natural sunlight. If the information is hard to find, ask for it. If you are a restaurant or business owner, share your actions and your supply chain knowledge with your customers.

As well as a broad understanding, supermarket food buyers need to have a detailed understanding of the issues in their area, and their managers need to make this possible. The specific issues are different for every type of product, so buyers need to consider it central to their work. For some it will be about working conditions and pay. For others it is all about fertiliser use. Or deforestation. Or air freight. Or meat alternatives. Or all of these and more.

For food professionals and everyday shoppers alike, everything we spend money on is an investment into one type of future or another (see page 159). We all need to push our money into the supply chains that we want to see thriving. Ask where, ultimately, will the money you spend end up?

Who will get richer, and what will they in turn invest in? Buying food is a powerful act.

What investments are needed into food land and sea?

We need investment in schemes that keep our forests and grow food sustainably. And we need research into the agricultural practices that can put carbon back into the ground, and more generally on the soil and biodiversity implications of different agricultural practices.

What we don't particularly need is research and development of techniques for increasing yields at the expense of biodiversity.

Many of the required improvements should not require multi-billion dollar investments. The single most important change will be an amazingly simple dietary shift towards less meat and dairy consumption, with a particular focus on reducing beef. This will markedly reduce greenhouse gases, improve the nutritional output of our land and, by relieving land pressure, ought to be pivotal in stemming deforestation. The net infrastructure investment requirement should be nothing or perhaps even less than that! We also need to cut waste throughout the food chain but, here again, the infrastructure requirements are not vast.

However, there are two critical areas for which investment is required. The first is research. We don't yet know nearly enough about the impact of different arable practices on the environment and, in particular, what farming systems store or release carbon and in what quantities. Research is needed into how to grow efficiently while encouraging biodiversity. There are promising manufactured alternatives to meat that need looking into further. We also need to understand how land can be used to create the liquid hydrocarbons that we will almost certainly need if we are to continue with aviation in the low carbon world.

The second critical investment area is farmers. We need to understand that the best ways of dealing with our land are not the cheapest. To do a really good job of producing food, cutting emissions and promoting biodiversity requires care and attention. It requires plenty of people. The good news is that we have more of this resource than ever before and will soon have at least another couple of billion more still. For the past couple of centuries we have been looking to minimise the number of people working on the land. This is crazy given the abundance of person power. We should be looking to employ *more* people to do a *better* and more careful job of looking after our land and growing our food. We need to invest in farmers and subsidise them to do the right things. The money for this can be made available by ceasing the deeply unhelpful subsidy of fossil fuels, divesting from them and better still, applying serious taxes.

Food action summary: What can I do and what can be done?

At the global level, here are the five things that will help most:

- Change the dietary trend from more meat and dairy to less.
- Create limits to first- and second-generation biofuel⁴³ (to take pressure off the agricultural system and allow development of agricultural practices that support biodiversity).
- Improve targeting and efficiency of fertiliser, pesticide and water.
- Eliminate phosphates from detergents.
- Greater establishment of protected areas in land, sea and freshwater.⁴⁴

At the personal level, here are the simple things that anyone can do:

- Buy and eat food in ways that enable a biodiverse agricultural system. Once again this takes us to lower consumption of meat and dairy, especially less beef and lamb, less waste, keep your fish consumption modest, and always from sustainable sources (see pages 38–39).

- Get to know your supply chains and buy food from the ones you like. In this way minimise the carbon, antibiotics, deforestation and slavery embodied in your meal. Maximise the biodiversity and quality of employment that lies behind every mouthful (see Investment, page 159).