Viva!

ENVIROCIDAL

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Foreword by Brendan Montague

We need to reinvent luxury. We need a better understanding of high quality. We need to treat ourselves, but treat ourselves well. Or to rediscover. The ancient Greek philosopher Epicurus was a hedonist, and spent a considerable amount of time pondering what made for a good life. When it came to food, he advised only bread and water which, he argued, always tasted sublime to a person experiencing real hunger.

For hundreds of years meat has occupied the territory of luxury. The old kings of England used the country as a hunting ground and paintings of the era show feasts resplendent with dead animals. Indeed, the foundation myth of our origins as humans is that we were apes rolling around in the forest undergrowth eating leaves until the desertification of the Savanna. Then we became man, upstanding, a hunter, an eater of meat. There is actually no evidence to support this, the prevailing hypothesis about what makes us human. And yet, if it is true, what does it tell us about ourselves? That we are a contented beast, a great animal surrounded by an abundance of food. The African forest contained all the wealth we early humans could possibly need – it was this environment rich in foods including plant proteins that allowed us to develop such a powerful mind. The transition to meat was in fact the act of desperation. The effective suckling of goats and cows in this story does not seem luxurious but really quite grim. The bleeding of cattle, and eventually the slaughtering of our fellow living creatures seems utterly dreadful. Yet this is the myth that is supposed to make eating meat a natural part of who we are.

So what does this mean for us today? I think we need to evoke the deep emotional relationship we have with food in order to influence behaviours towards what is healthy for us as human beings and also what is sustainable for our planet. We need to celebrate plant food, and build customs and myths that place the beetroot and the potato at the centre of our celebrations, of our identities. Luxury, when one really digs into its meaning, is simply that which is not affordable to everyone. We show off by eating meat. But meat is cheap, and dirty, and everywhere. Real luxury is organic foods, locally sourced foods, home grown foods, plant based food. These foods need to be rich with stories – grown by those we love, only for us, over time and with great care. Meat in turn needs to be treated with disgust. As a journalist, I have seen the new mega farms spreading into British agriculture like mould. The cows are chained, clearly in pain, barely able to suffer the weight of their bloated udders. Thousands of them. Living within the rivers of slurry they produce. It's not luxury, it is despair, and it is disgusting.

The publication of this second edition of the Envirocidal report could not be more timely. Sir David Attenborough has finally taken the message to middle England that climate change is an existential threat. The inspiring and innovative manifestation of Extinction Rebellion, with more than a thousand people willing to be arrested peacefully protesting in London, and the direct actions simultaneously taking place in cities around the world, show that people of all ages are determined to act on climate change – and also biodiversity loss. Veganism is becoming the new normal. I became vegan this year after holding a vote of readers of *The Ecologist* asking whether its editor could have a pescatarian diet without some level of hypocrisy. The answer was resounding. And as this report makes clear, eating fish and foregoing other meat is not sufficient if we want to significantly reduce our personal climate impacts – and lead in our communities and in our countries on carbon reduction.

This report is most valuable because it provides a comprehensive review of the current scientific literature. While it is an appeal to emotion and identity that will influence behaviour, we really do need to be confident about our claims before we go into the world making demands of other people. We need to be clear about the rational arguments, as well as the emotional appeal. This report sets out beyond reasonable doubt that continuing to eat meat is irrational, and dangerous. It reveals exactly how livestock farming is linked to all the main areas of concern including global warming and climate change, land and water use, overfishing, biodiversity loss, deforestation,

desertification, air pollution, antibiotic resistance, world hunger and food waste.

Those of us who are already committed to environmentalism now have to face up to the fact that the vegan diet (perhaps peppered with the occasional supplement) is the only truly green diet. The best solution to the compound crises of climate, biodiversity, soil depletion is to simply stop eating animals. A global switch to diets that rely less on meat, fish, dairy and eggs and more on fruit and vegetables could make a huge difference to us and future generations.

I am also encouraged that this report talks about government action. We can only do so much as individuals and fundamental change will come only through changes in how we eat, how we farm, how we produce at a national and international level. We need to lobby, transform and replace many of the institutions that form our civil society. Our schools can no longer have any ethical authority while serving meat based meals to our children. Our hospitals cannot serve meat that, in time, will make patients sick. The government needs the Green Pea Marketing Board, sending free food into our schools just as when I was young we were given free milk. But ultimately, we need to change our feelings about food. Plants are healthy, rich, plentiful and tasty – they are luxurious. Spice is very obviously the spice of life. Animals bring us tremendous joy especially as companion animals – but the idea that they should be minced and ground down to form part of our diets is macabre and grotesque.

This report explains the many benefits of moving to a plant-based diet. But this is not about sacrificing meat, it's about discovering that we can and must do so much better.

Brendan Montague, Editor, *The Ecologist*

Executive summary

Global warming isn't a prediction – it's happening around us right now. It's happened before, around 55.5 million years ago, when a burst of CO_2 raised the Earth's temperature by 8°C. It had major impacts on plants and wildlife and took 200,000 years for the planet to recover.

This time it's caused by human activity – and livestock farming is one of the main culprits. Greenhouse gas emissions from livestock production arise from a range of factors. Enteric fermentation (cows burping and farting methane), gases from animal manure (methane again), deforestation for grazing land and soya-feed production, soil carbon loss in grazing lands, energy used in growing animal feed, processing and transporting animal feed and meat and nitrous oxide releases from nitrogenous fertilisers all contribute.

Governments have joined together to try and limit global temperature rise to less than 2°C above pre-industrial levels – a critical threshold above which scientists believe would have devastating effects.

We're not doing very well – in 2015, global temperatures broke through the 1°C barrier as the amount of greenhouse gases in the atmosphere reached an all-time high. So, we are now already halfway to the 2°C and very close to reaching 1.5°C. If we are going to avert an environmental disaster, we must take urgent action.

Some experts warn that current trends could lead to a 4-5°C increase of global temperatures by the end of this century. If the warnings are ignored, human-related climate change will lead to a whole new range of health risks, the like of which we have never seen before: polar ice melting, rising sea levels, flooding, drought, water shortages, loss of biodiversity, mass extinctions, hurricanes, tornadoes, starvation, infectious disease outbreaks, conflict and warfare.

This may sound like science fiction but some scientists say if we don't act soon to curb climate change, we could be heading towards a situation resembling the world ravaged by drought and hardship seen in the futuristic film "Mad Max: Fury Road".

As food production expands to meet the world's growing appetite for meat, emissions from livestock farming continue to rise. The only way to stop this is to change the way we eat, drastically reducing animal food production. Simply using energy-efficient light bulbs or switching to an electric car will make little difference if you continue tucking into steak and eating burgers.

Our oceans are being decimated and ancient coral reefs destroyed at an unprecedented level. Marine ecosystems are collapsing as industrial bottom-trawlers plough through sea beds with no consideration of the consequences. This is unprecedented in the history of animal life and may disrupt ecosystems for millions of years to come.

Three-quarters of the world's food comes from just 12 plants and five animal species. Massive livestock populations have profound consequences for biodiversity because of deforestation, change of land use, overgrazing, degradation of grasslands and desertification. Loss of habitats and species extinction are taking place at an alarming rate. Human activity is pushing life toward a sixth mass extinction and natural ecosystems are degrading at an unprecedented rate.

Deforestation remains alarmingly high in many parts of the world. Part of the problem is food imports – it may look like we are improving matters on our own doorstep but really the problem is just moving elsewhere. This is known as 'carbon leakage' and of course, it does not reduce global emissions.

Desertification and land degradation are being driven by the expansion of livestock farming and the production of animal food. Drastic action is required immediately if we are to attempt to halt and reverse it.

The alarming rise in antibiotic-resistant bugs is a problem of our own making, a direct consequence of the inappropriate use of antibiotics in livestock farming. Many farmers routinely use antibiotics to promote growth and prevent disease in healthy animals. In some countries, a huge proportion of medically important antibiotics are used in this way.

Most people assume that industry and traffic are the main causes of air pollution. However, agriculture is the single biggest cause of air pollution in Europe, contributing more than residential energy use or power generation. Reducing air pollution could mean the

difference between life and death for millions of people every year.

One in nine people in the world today are undernourished, yet we feed around a third of our global crop production to animals. Growing food for human consumption, without feeding it to animals, could feed an additional four billion people – more than enough for everyone for years to come! We all know how wasteful old gas-guzzling cars are – how long before livestock farming is viewed the same way?

Animal foods require far more precious water than most plants foods. Half a billion people in the world face severe water scarcity all year round. We have already seen how severe drought contributed to the conflict in Syria. There is a direct path leading from climate change to drought, to agricultural collapse and mass human migration. Now it looks like Yemen may be the first country to actually run out of water. Which country will follow? Pakistan, Iran, Mexico or Saudi Arabia? Will future conflicts be fought over water rather than oil? Some scientists believe so. A shift in eating habits towards a plant-based diet could play an important role in preserving water and reducing global hunger and malnutrition.

We may have a global economy, but the huge disparities between rich and poor, and the persistent depletion of environmental resources used in food production on land and at sea, prevent us from reducing the very basic public-health problem of world hunger. On top of that we throw a huge amount of food away! If food waste were a country, it would be the third largest emitting country in the world. In the UK, the average family throws away £700 worth of perfectly good food a year.

The global demand for animal foods will continue to rise unless governments actively promote changing the diet. There is a clear need for a strategic, integrated approach to agriculture, forestry and other policies linked to how we use the planet's natural resources. The best solution is to stop eating animals. A global switch to diets that rely less on meat and more on fruit and vegetables could save eight million lives by 2050 and reduce greenhouse gas emissions by two thirds. We talk the talk with sustainable energy and electric cars – let's walk the walk with diet!

Global warming

"Global warming isn't a prediction. It is happening"
James Hansen – former NASA Scientist

According to scientists, we have now entered a new geological period in history, the Anthropocene epoch, where human activities are directly responsible for global environmental changes (Steffen *et al.*, 2007).

What is global warming?

The term 'global warming' refers to the rising temperature of Earth's climate system caused by man-made greenhouse gases such as carbon dioxide (CO_2). It's also known as climate change.

The Earth's atmosphere acts as a protective layer, letting sunlight in and retaining heat. The gases in the atmosphere act a bit like the glass walls of a greenhouse, trapping the sun's heat and stopping it from escaping back into space. Think of greenhouse gases like throwing an extra blanket on the bed, then another one, then another one! Many of these gases occur naturally, but human activity is increasing the concentrations of them in the atmosphere.

Any activity involving the combustion of fossil fuels contributes; this includes electricity generation, heating, transport, industry and agriculture – including livestock farming. This activity is adding enormous amounts of greenhouse gases to the atmosphere, increasing the greenhouse effect leading to global warming.

Greenhouse gases

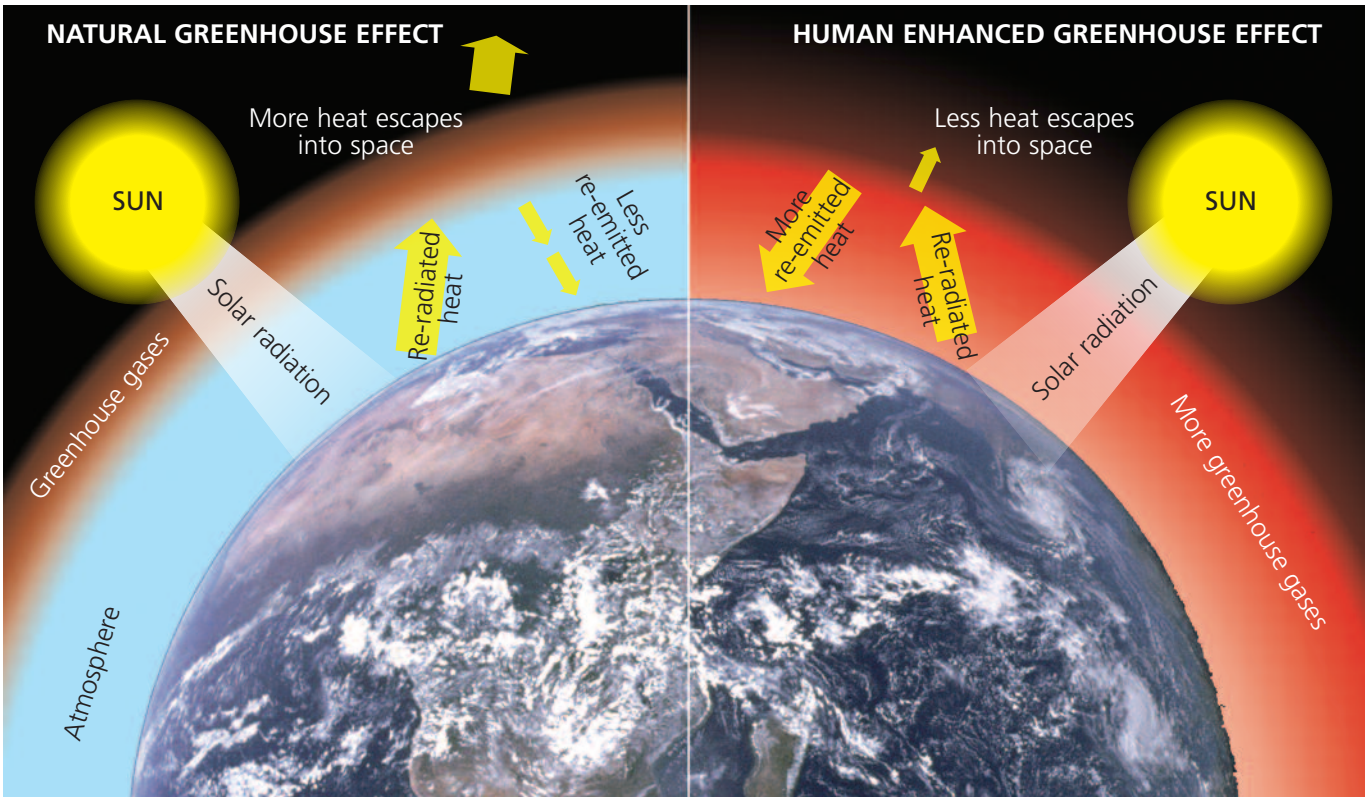
The largest contributor to global warming is carbon dioxide (CO_2). Other greenhouse gases are emitted in smaller quantities, but trap heat far more effectively than CO_2 and can be many times stronger.

The main three greenhouse gases are:

- **Carbon dioxide (CO_2)**
- **Methane (CH_4)**
- **Nitrous oxide (N_2O)**

Four others are collectively known as the 'F-gases':

- **Hydrofluorocarbons (HFCs)**
- **Perfluorocarbons (PFCs)**

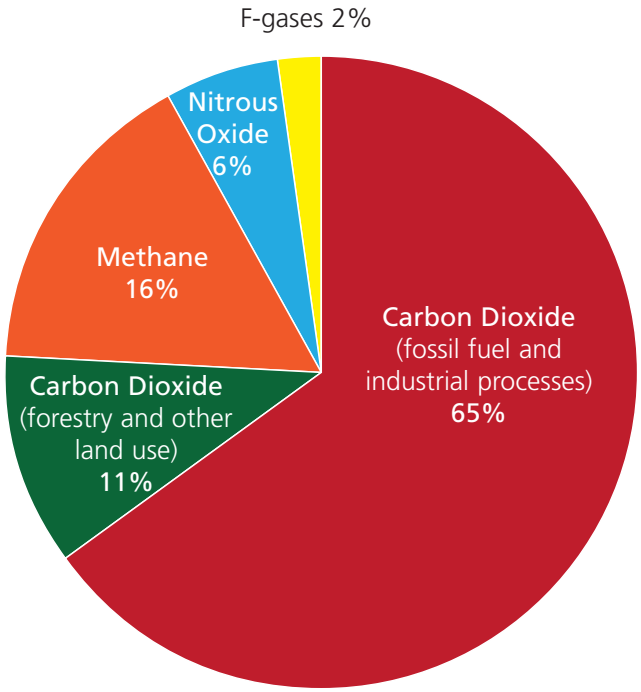


- Sulphur hexafluoride (SF_6)
- Nitrogen trifluoride (NF_3)

Source: NAEI, 2016.

CO_2 is the biggest contributor of greenhouse gases, contributing around three-quarters (76%) of all gases (65% from fossil fuels and 11% from forestry and land use changes), methane contributes 16%, nitrous oxide 6% and the F-gases make up the remaining 2% (IPCC, 2014).

GLOBAL GREENHOUSE GAS EMMISSIONS BY GAS



Source: IPCC, 2014.

CARBON DIOXIDE (CO_2)

CO_2 is the greenhouse gas most commonly produced by human activity. Fossil fuel burning and industrial processes are the main sources – responsible for 65% of man-made global warming (IPCC, 2014).

When land is cleared there are fewer trees to remove CO_2 from the atmosphere and if trees are burned or left to rot, additional CO_2 is released into the atmosphere. So, CO_2 emissions can also be attributed to deforestation, land clearing for agriculture and degradation of soils. This type of activity accounts for around 11% of man-made global warming (IPCC, 2014; EPA, 2017).

CO_2 concentration in the atmosphere is now 40% higher than when industrialisation began (European Commission, 2017).

METHANE (CH_4)

Agriculture is the main contributor of methane which is responsible for 16% of man-made global warming (IPCC, 2014).

Rotting liquid manure (faeces and urine) in lagoons, ponds and tanks produces significant quantities of methane as it rots. So vast amounts arise from dairy farms, cattle feedlots and intensive pig farms (Carlsson-Kanyama and González, 2009).

Furthermore, ruminant animals (cows, goats, sheep, giraffes, yaks, deer and antelope) have a specialised stomach called a rumen in which tough plant fibres called cellulose and complex carbohydrates are digested or broken down by bacteria into simple molecules that the animal can absorb into their bloodstream. This is called '**enteric fermentation**' and it produces substantial amounts of methane in the form of burps and farts! Cows produce the most methane, so **because of their immensely huge numbers, beef and dairy cows, contribute significantly to global warming**.

NITROUS OXIDE (N_2O)

Agriculture is also the main contributor of nitrous oxide which is responsible for 6% of man-made global warming (IPCC, 2014; European Commission, 2017). Fertiliser is the primary source, but manure lagoons associated with large-scale pig farms emit a substantial amount too.

WHAT ARE CO2-EQUIVALENTS?

'Carbon dioxide equivalent' or 'CO_2e' is a way of describing the global warming potential (GWP) of different greenhouse gases in a common unit. The idea is to express the impact of any greenhouse gas in terms of how much CO_2 would produce the same amount of global warming. Over a 100-year period, methane is 28 times more potent than CO_2, and nitrous oxide is 265 times more potent. So one ton of methane has the same effect as 28 tons of CO_2.

- 1 methane = 28 x CO_2
- 1 nitrous oxide = 265 x CO_2

The GWP values provided here do not include climate-carbon feedbacks (which would increase the figure for methane to 34 and nitrous oxide to 298).

Source: IPCC, 2014.

How fast is global warming happening?

Since the industrial revolution in the 18th century, humans have been producing greenhouse gases in ever-increasing amounts. As a result, the amount of greenhouse gases in the atmosphere is now higher than at any time in human history. Global warming is already happening and is escalating in such a way that we may soon reach a critical tipping point, beyond which the future looks very uncertain, even if emissions are then reduced.

Annual greenhouse gas emissions grew on average by 2.2% per year from 2000 to 2010, compared to 1.3% per year from 1970 to 2000 (IPCC, 2014).

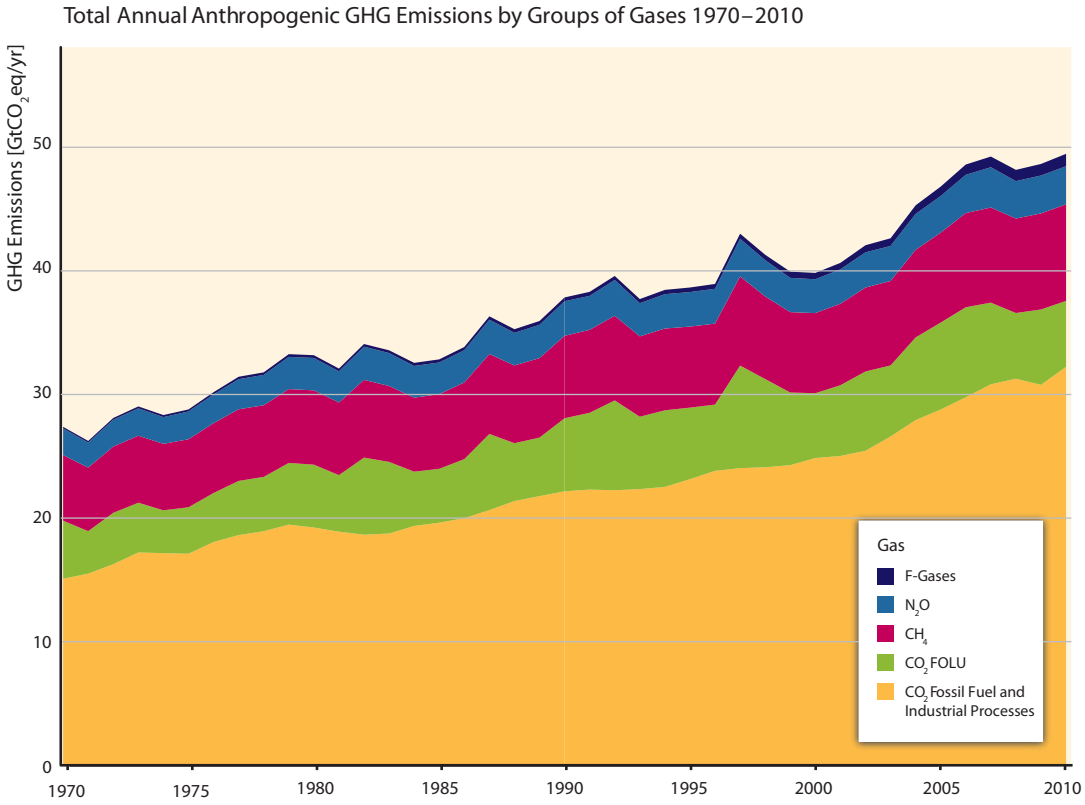
Global greenhouse gas emissions are now at the highest level they have ever been in human history.

The United Nations' Intergovernmental Panel on Climate Change (IPCC) says:

"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and oceans have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased" (IPCC, 2013).

While concerted efforts have been made in some areas to reduce emissions, **greenhouse gas emissions from livestock have increased globally by 51% from 1961 to 2010** because of increased demand for animal foods (Caro *et al.*, 2014).

GLOBAL GREENHOUSE GAS EMISSIONS FROM 1970 TO 2010



- Each of the last three decades has been successively warmer than any decade since 1850 (when records began).
- The period from 1983 to 2012 was the warmest 30-year period in the Northern Hemisphere in the last 1400 years.
- From 1880 to 2012, the global average temperature increased by 0.85°C. This may not sound like much but we are now seeing the effects.

Source: IPCC, 2014.

Has it happened before?

Yes! Around 55.5 million years ago a large burst of CO_2 raised the Earth's temperature by 8°C, which had major impacts on plants and wildlife. This event is known as the Paleocene-Eocene thermal maximum (PETM) and it took 200,000 years for the planet to recover. Scientists say it may have been triggered by a preceding burst of the greenhouse gas which released similar levels of gases to those we are seeing today (Bowen *et al*., 2015).

It's unclear what caused this initial release but scientists say it may have warmed the Earth's atmosphere by 2-3°C (similar to levels predicted by the end of this century). When this heat reached the ocean floor, scientists suggest it melted methane ices called clathrates, releasing huge bursts of methane into the ocean and then the atmosphere. Methane is many times more potent than CO_2, so sudden spikes in emissions could cause huge climate change (McInerney and Wing, 2011).

"PETM may be a strong analogue for anthropogenic [man-made] global change in terms of both magnitude and rates of change" (Bowen *et al.*, 2015).

The PETM is an example of catastrophic global warming triggered by the build-up of greenhouse gases in the atmosphere. We are currently pumping similar levels of CO_2 into the atmosphere right now, raising concerns that this may also destabilise the Earth's climate, triggering an environmental disaster.

Kyoto, Paris and beyond…

The Kyoto Protocol was an international agreement linked to the United Nations' Framework Convention on Climate Change (UNFCCC). It was the first agreement between nations to attempt country-by-country reductions in greenhouse gas emissions. It was finalised in Kyoto, Japan, in 1997 and came into force in 2005 (UNFCCC, 2017). It set mandatory targets for reducing greenhouse gas emissions for countries that signed up to it. From 2008 to 2012, participating nations committed to reducing emissions by an average of 5.2% below 1990 levels.

However, it allowed 'carbon trading' whereby countries exceeding their targets could off-set that against countries whose emissions were lower. Put simply, carbon trading is the process of buying and selling permissions to pollute (Fern, 2010). Some countries only achieved their targets by buying carbon credits and others from 'carbon leakage' – shifting emissions by moving production to developing countries such as China. Carbon trading does nothing to reduce emissions, it simply moves them elsewhere.

Overall, emissions from participating nations fell, but emissions in the rest of the world increased sharply – especially in China and other emerging economies who export goods to richer countries (Peters *et al.*, 2011).

Glen Peters, from the Centre for International Climate and Environmental Research in Oslo said: ***"Our study shows for the first time that emissions from increased production of internationally traded products have more than offset the emissions reductions achieved under the Kyoto Protocol … this suggests that the current focus on territorial emissions in a subset of countries may be ineffective at reducing global emissions without some mechanisms to monitor and report emissions from the production of imported goods and services"*** (Clark, 2011).

A second period from 2013 to 2020 bridges the gap between the first Kyoto period and the Paris Agreement. During this time, parties are committed to reducing emissions by at least 18% below 1990 levels. The European Union (EU) agreed to cut emissions by 20% by 2020 (European Commission, 2017a).

The Paris Agreement (also referred to as COP21) came into force on 4 November 2016, after the 'double threshold' was met – when 55 countries accounting for at least 55% of global emissions had signed up (UNFCCC, 2017a). Since then, more countries have joined, reaching a total of 125 countries in early 2017.

The aim is to strengthen the global response to the threat of climate change by keeping the global temperature rise this century below 2°C above pre-industrial levels but to try and limit the increase to 1.5°C.

The 1.5°C lower limit offers the planet a better chance of preventing catastrophes such as the melting of polar ice (which would no longer be able to deflect solar radiation) and lead to even greater global warming. Sea ice reflects about 50% of the solar radiation it receives back into space. By contrast, water reflects less than 10%. So if you replace ice with water, which is darker, much more solar heat will be absorbed by the ocean and the planet will heat up even more rapidly.

Similarly, coral reef destruction and extreme sea level rises might be avoided if the lower limit is achieved. Starting from 2023, governments will come together every five years for a 'global stocktake' based on the latest science and progress to date.

The 2008 Climate Change Act committed the UK Government to reducing greenhouse gas emissions to levels at least 80%, lower than those in 1990 by 2050 (Defra, 2016). In terms of food production, this should mean relying less on imports, which effectively transfer the emission effect of food consumption to other countries – a process known as 'carbon leakage' (Defra, 2016).

If 'land use change' emissions are taken into account, then about a half of the emissions from food production for the UK arise outside the UK (Audsley *et al.*, 2009). The UK currently imports over 50% of its food and animal feed, so the environmental impact of our food supply is increasingly displaced overseas (de Ruiter *et al.*, 2016).

Mission impossible?

The 2°C limit is a critical level above which climate researchers believe an increase would take the world into unchartered territory leading to extreme weather and climate feedbacks that could accelerate the melting of polar ice and cause dangerously high sea levels. But is it possible to keep below 2°C or even 1.5°C, or is it already too late?

IPCC says that we can still stop global warming but it's going to be tough as right now, the world is failing badly at reaching its climate goals. Stanford University's Professor Chris Field, co-chair of the IPCC working group on adaptation to climate change, said: ***"…I would say the 1.5°C goal now looks impossible or at the very least, a very, very difficult task."***

In 2013, the Food and Agriculture Organisation of the United Nations published the report *Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities.* They said: *"Assuming a maximum GHG* [greenhouse gas] *emission reduction rate of five percent per year, the 1.5°C target is probably already unachievable and the 2°C target will also be missed if no action is taken prior to 2027"* (Gerber *et al.,* 2013).

In 2015 global temperatures broke through the 1°C barrier as the amount of greenhouse gases in the atmosphere reached an all-time high (Met Office, 2016).

So we are already halfway to the 2°C limit and very close to reaching 1.5°C. If we are going to avert an environmental disaster, we have to take urgent action. Meeting the lower limit may now mean overshooting and coming back down using negative emissions technologies that 'suck' CO_2 out of the air – like planting trees where there were previously none (afforestation) or restoring areas where trees have been cut down (reforestation).

A report by the United Nations' Environment Programme (UNEP), released in London a day before the Paris Agreement came into force, predicted that 2030 emissions will exceed the levels needed to keep global warming below the crucial 2°C. **The report warns that without swift reductions, the world is on track for a temperature rise of 2.9-3.4°C this century**, even if the pledges agreed in Paris are met (United Nations, 2016).

Erik Solheim, head of UNEP said: ***"Though the Paris Agreement may slow climate change, it's still not quite good enough if we are to stand a chance of avoiding serious climate change. If we don't start taking additional action now… we will grieve over the avoidable human tragedy. The growing numbers of climate refugees hit by hunger, poverty, illness and conflict will be a constant reminder of our failure to deliver. The science shows that we need to move much faster. None of this will be the result of bad weather. It will be the result of bad choices by governments, private sector and individual citizens. Because there are choices…"*** (UN News Centre, 2016).

More recently, the 2017 edition of UN Environment's Emissions Gap report, released ahead of the UN Climate Change Conference in Bonn, found that national pledges only bring a third of the reduction in emissions required by 2030 to meet climate targets, with private sector and sub-national climate change action not increasing at a rate that will help close this worrying gap. The gap between international goals and domestic commitments to cut greenhouse gas emissions leaves the world on course for warming well beyond the Paris climate target of 2°C and may go beyond 3°C by 2100 (UNEP, 2017).

Some experts warn that **current trends could lead to a 4-5°C increase of global temperatures by the end of this century**, compared to pre-industrial levels. The IPCC say that this would pose large risks to global food security (IPCC, 2014).

There may still be time to turn things around and the benefits of certain actions could be felt relatively quickly. Professor Peter Stott, Acting Director of the Met Office Hadley Centre said: ***"It is necessary to reduce greenhouse gas emissions rapidly to help avoid the most dangerous impacts of climate change, but it had been thought that most of the benefits of this early mitigation would be felt only much later in the century. This new research shows that many people alive today could see substantial benefits of efforts to reduce emissions thanks to a greatly reduced risk of heat waves in as little as two decades"*** (Met Office, 2017).

The key message is that stopping the increase of greenhouse gas emissions from livestock farming should be a top priority because it could slow global warming very rapidly (McMichael *et al*., 2007).

Consequences

If we don't control climate change now some of these changes will happen:

- Sea levels will rise
- Glaciers and sea ice will melt
- Coastal cities will flood
- Places that get lots of rain and snowfall will get hotter and drier
- Lakes and rivers will dry up
- Droughts will make it hard to grow crops
- There will be water shortages
- Many plants and animals will become extinct
- Hurricanes, tornadoes and storms will get more common

Source: EKOenergy, 2017.

The sea has been rising at a rate of 1.7 mm a year since 1900, but this has almost doubled to 3.2 mm a year since the end of 20th century (Mimura, 2013). When described in millimetres, it doesn't sound like much to worry about but if the speed at which sea levels are rising continues to accelerate, we can expect a large rise in sea levels this century and it will only get worse in the centuries to come.

The IPCC has predicted a sea level rise of up to one meter by 2100, if emissions are not reduced. This could lead to floods in New York, London, Sydney, Vancouver, Mumbai and Tokyo and leave the surrounding areas vulnerable to storm surges (coastal flood or tsunami-like phenomenon of rising water).

Dr Andra Garner of Rutgers University, New Jersey, fears that if we don't reduce greenhouse gas emissions, New York could be facing storm surges of more than 15 metres above the current sea level by 2300 (Garner *et al.*, 2017).

Breaking bad

Some say the IPCC's estimates of sea level rises of one metre by 2100 are too conservative as they don't factor in disintegration of polar ice sheets. In 2017, a huge ice shelf in Antarctica called Larsen C developed a rift 175 kilometres long and half-a-kilometre wide and a giant iceberg, quarter the size of Wales, broke off and drifted into the Weddell Sea.

Shelves like this act as a barrier, holding back glaciers that feed it and following the collapse of the more northerly Larsen A ice shelf in 1995 and Larsen B in 2002, all eyes have been on Larsen C for some time.

The Greenland Ice Sheet (GIS) and West Antarctica Ice Sheet (WAIS) contain ice equivalent to about seven metre and 3-5 metre sea-level rise, respectively. The GIS alone could cause a **seven metre sea-level rise** if a 3°C increase in global average temperature above pre-industrial levels occurs (Church *et al.*, 2001). If this higher temperature persists, an irreversible condition, where the GIS never recovers, will be triggered even if the temperature returns to lower values later (Robinson *et al.*, 2012).

Continued growth in greenhouse gas emissions could trigger an unstoppable collapse of Antarctica's ice **raising sea levels by more than a metre by 2100 and more than 15 metres by 2500** (DeConto RM and Pollard, 2016). Currently, about 40% of the world's population lives within 100 km (about 63 miles) of the sea. These potential sea-level rises pose significant threats to coastal areas around the world.

Counting the cost

The *Stern Report* discussed the effect of global warming on the **world economy**. They said cutting greenhouse gas emissions would cost a lot of money (about 1% of the world's GDP), but **doing nothing will cost the world a lot more**, anything from five-20 times more. They warned that we face losing up to a fifth of the world's wealth from unmitigated climate change that if unchecked, **will devastate the global economy on the scale of the Great Depression or the 20th century's world wars** (Stern, 2006).

Climate change will also affect food yields around the world. Many areas (for example sub-Saharan Africa) are likely to be affected, in terms of both nutrition and incomes (McMichael *et al.*, 2007). Over just two decades, Southern Africa could lose more than 30% of its main crop, maize, by 2030 and in South Asia, losses of many regional staples, such as rice, millet and maize could be as high as 10% (Lobell *et al.*, 2008).

These are just some of the reasons why climate change will affect the lives and safety of large numbers of people.

Livestock production

The true cost of 'cheap meat' is becoming more and more evident. Today, livestock production is one of the top contributors to serious environmental problems including the emission of greenhouse gases and global warming.

A 2017 landmark study found that the top three meat firms – JBS, Cargill and Tyson – emitted more greenhouse gases in 2016 than all of France (GRAIN *et al.*, 2017).

In 2018, the new Coller FAIRR Protein Producers Index found that three out of four (72%) of the world's biggest meat and fish companies provided little or no evidence to show that they were measuring or reporting their greenhouse gas emissions (FAIRR, 2018). The index includes giants like the Australian Agricultural Company, which has the biggest cattle herd in the world, the Chinese WH Group, the largest global pork company and the US's Sandersons, which processes more than 10 million chickens a week. Together, the companies make up around one-fifth of the global livestock and aquaculture market – that's one in every five burgers, steaks or fish.

In 2006, it was estimated that livestock accounts for around a fifth (18%) of all man-made greenhouse gas emissions (FAO, 2006). This figure was based on the United Nations' comprehensive analysis in their report *Livestock's Long Shadow*. It includes the production of draft power (animals used for pulling heavy loads), eggs, wool and dairy products.

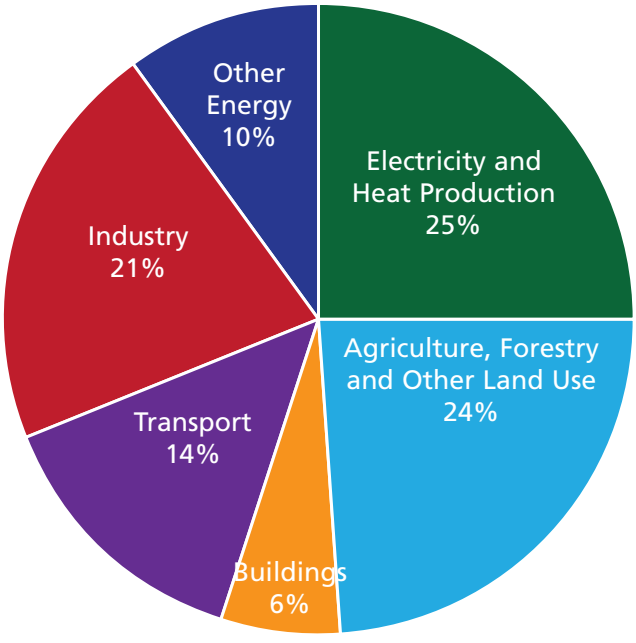
A later estimate from them puts the figure at 14.5%, but only includes meat, poultry, eggs and dairy production (Gerber *et al.*, 2013).

However, the situation may be even worse than previously thought. Revised calculations show that global livestock emissions in 2011 were 11% higher than estimates made by IPCC in 2006 (Wolf *et al.*, 2017). The reason the figure may be so much higher is that breeding and feeding methods have changed, so earlier estimates were based on out-of-date data. Dr Julie Wolf, of the US Department of Agriculture (USDA), Agricultural Research Service said: *"In many regions of the world, livestock numbers are changing, and breeding has resulted in larger animals with higher intakes of food. This, along with changes in livestock management, can lead to higher methane emissions"* (BMC, 2017).

The United Nations' ground-breaking report, *Livestock's Long Shadow* surprised some people when it revealed how livestock farming is responsible for more greenhouse gas emissions than all the world's transport – cars, buses, trucks, trains, ships and planes – put together (FAO, 2006).

Henning Steinfeld, Chief of the Food and Agriculture Organisation's Livestock Information and Policy Branch and senior author of the report said: ***"Livestock are one of the most significant contributors to today's most serious environmental problems. Urgent action is required to remedy the situation"*** (FAO, 2008).

GLOBAL GREENHOUSE GAS EMISSIONS BY ECONOMIC SECTOR



Source: IPCC, 2014.

In 2014, the IPCC said that around a quarter (24%) of all global greenhouse emissions come from agriculture, forestry and other land use (AFOLU) – more than from industry at 21% or from transport at 14% (IPCC, 2014). Livestock production contributes about 80% of the gases produced by agriculture (McMichael et al., 2007).

In 2014, the IPCC said that around a quarter of all global greenhouse emissions – about the same as industry and more than transport – came from agriculture (IPCC, 2014) with livestock production contributing about 80% of that (McMichael *et al.,* 2007).

Emissions from livestock production are calculated based on the following:

- **Deforestation for grazing land and soya-feed production**
- **Soil carbon loss in grazing lands**
- **Energy used in growing feed-grains**
- **Energy used in processing and transporting feed grains and meat**
- **Nitrous oxide releases from the use of nitrogenous fertilisers**
- **Gases from animal manure (especially methane)**
- **Enteric fermentation**

Source: McMichael *et al.*, 2007.

Studies show that livestock production accounts for around 9% of all CO_2 emissions, 35-40% of methane emissions and 65% of nitrous oxide emissions (McMichael *et al.*, 2007).

Asia (specifically China and India) is the source of the most enteric methane emissions (around 33% of the global total), mostly from cattle, with Latin America (23.9%), Africa (14.5%), Western Europe (8.3%) and North America (7.1%) also being significant sources (O'Mara, 2011).

Recent research suggests that **methane emissions from livestock have increased by 332% since the 1890s** (Dangal *et al.*, 2017) and are projected to grow by a further 30% in the two decades from 2000 to 2020. Asia (especially China), Western Europe and North America are the regions with the highest greenhouse emissions from manure (O'Mara, 2011).

The industry suggests that developing technologies can be used to reduce emissions. This includes improving energy efficiency, reducing fuel use, using new vehicles or machinery, farms producing their own 'clean' energy

and improving efficiency in manure management (Defra, 2012). Some factory farms use methane digesters to produce electricity. This technology may reduce methane emissions but doesn't eliminate solid waste and typically requires large subsidies to remain economically viable. So, despite being touted as a 'clean' energy source, methane digesters effectively serve to further entrench the environmentally destructive model of industrial livestock production.

Scientists say that available technologies for reducing emissions from livestock would reduce them by less than 20% (McMichael *et al.,* 2007). Current trends in yield improvement will not be sufficient to meet projected global food demand by 2050. Changing the way we farm animals will not be enough, **a decrease in agriculture-related emissions can only be achieved by a reduction in demand for animal foods** (Bajželj *et al*., 2014).

If nothing changes, greenhouse gas emissions from livestock will continue to rise as food production expands to meet the increasing demand from the world population which is expected to reach 8.6 billion by 2030 and 9.8 billion by 2050 (UN DESA, 2017).

Writing in the *Lancet*, scientists said: ***"Assuming a 40% increase in global population by 2050 and no advance in livestock-related greenhouse gas reduction practices, global meat consumption would need to fall to an average of 90g per person per day just to stabilise emissions from this sector"***. This would mean a substantial drop in meat consumption in wealthy countries and restricted growth in demand in developing countries, especially of red meat from ruminants (McMichael *et al.,* 2007).

Greenhouse gas emissions from livestock production warrant the same scrutiny as emissions from driving and flying. This does not mean just dropping meat – after beef, dairy is the most emissions-intensive livestock product accounting for 20% of the total greenhouse gases emitted by livestock (Gerber *et al.*, 2013).

Emissions from the global dairy sector account for 4% of the total global greenhouse gas emissions (Gerber *et al.*, 2010). This is a significant amount, especially when you consider that it is coming from just 25% of the global population – 75% of the world's population is lactose intolerant and do not consume milk or dairy products.

In terms of animal food production in the EU, the dairy sector produces the most greenhouse gases, closely followed by beef (Lesschen *et al.*, 2011). However, when you look at the efficiency rates (converting feed into

food) in terms of kg CO_2e per kg beef is the worst at 22.6 kg CO_2e per kg followed by pork (3.5), eggs (1.7), poultry (1.6) and milk (1.3) (Lesschen *et al.*, 2011). The obvious solution is to stop eating all animal foods.

THE BEEF WITH BEEF

Beef production is by far one of the most damaging industries worldwide. It is responsible for the release of CO_2, methane and nitrous oxide, vast loss of carbon sinks in changing land use, biodiversity loss, rainforest destruction, water pollution and excessive water wastage. Beef is one of the most inefficient foods you could possibly eat as much of the food cows eat is excreted when humans could consume those calories directly. As for soya, the vast majority of soya grown is fed to cattle raised for meat, which is another reason beef tops the charts.

Importing animal foods is not the answer. Whilst agricultural production in the UK may have declined since 1990, some domestic production (in particular meat) has been replaced with imports. Therefore, any reduction of emissions in the UK will have been at the expense of increases overseas. This is known as 'carbon leakage' as it does not reduce global emissions.

"...agricultural activity in UK emissions has to be viewed in the broader policy context, including the demand for food. Avoiding action to reduce emissions in the UK could result in 'carbon leakage', where production moves abroad. This would not reduce global GHG [greenhouse gas] *emissions and could put pressure on sensitive landscapes or habitats."* (Defra, 2012).

The best solution is to stop eating livestock products, mirroring the widely supported strategy proposed for greenhouse gas emissions in general. We talk the talk with sustainable energy and electric cars – let's walk the walk with diet!

The health effects

A diet that is good for you is also good for the planet. A vegan diet is closer to the World Health Organisation's public health recommendations and has a considerably lower environmental effect than a typical Western diet, which requires more water, more land, more energy, more fertiliser and more pesticides.

In the UK, a 50% reduction in meat and dairy consumption (replacing them with fruit, vegetables, pulses and wholegrain foods), could result in a 19% reduction in greenhouse gas emissions and prevent over 43,000 deaths a year (Scarborough *et al.*, 2012).

This would benefit health, mainly by reducing the risk of heart disease (especially related to saturated fat in meat and dairy foods), obesity, bowel cancer and some other cancers (McMichael *et al.*, 2007). The widespread adoption of a vegan diet would be even more effective.

A global switch to diets that rely less on meat and more on fruit and vegetables could save eight million lives by 2050, reduce greenhouse gas emissions by two thirds, lead to huge healthcare-related savings and avoid climate change damages of $1.5 trillion (Springmann *et al.*, 2016).

Dr Marco Springmann, of the Oxford Martin Programme on the Future of Food said: ***"The size of the projected benefits should encourage individuals, industry and policymakers to act decisively to make sure that what we eat preserves our environment and health".***

Springmann's team found that moving to diets with fewer animal foods would have major health benefits; **following dietary guidelines would save 5.1 million lives a year, a vegetarian diet would save 7.3 million but a vegan diet would save 8.1 million lives** (Springmann *et al.*, 2016).

The European Prospective Investigation into Cancer and Nutrition (EPIC) study is one of the largest cohort studies in the world, with more than half a million participants recruited across 10 European countries, followed for 15 years. The EPIC team investigated if an environmentally friendly diet is also a healthier one. They found that replacing meat with vegetables, fruit, nuts, seeds, pasta, rice or couscous not only lowered the risk of an early death but reduced environmental burden too (Biesbroek *et al.*, 2014).

Researchers from California comparing the diets of Seventh Day Adventist vegetarians (not vegans) and meat-eaters found evidence for the much higher environmental cost of an animal-based diet. The differences resulted primarily from the inclusion of beef in the diet of the meat-eaters whose diet required 2.9 times more water, 2.5 times more energy, 13 times more fertiliser and 1.4 times more pesticides than a vegetarian diet. This finding is similar to those published by groups in Europe, Japan, the US and Australia (Marlow *et al.*, 2009).

Lead author of this study, Dr Hal Marlow, said ***"Almost everyone has some knowledge that it costs less***

environmentally or is healthier to be a vegetarian, but there's no understanding yet of really what that means until you put some numbers behind it" (Marlow *et al.*, 2009).

Comparing different diets can be very useful. The American Water Works Association say that the average person uses around 1,835 litres (485 gallons) of water inside the home per week. They say that you can save around 35% of that by installing more efficient water fixtures and regularly checking for leaks. However, the Adventist vegetarian diet conserves the equivalent of 54% of the average weekly per capita indoor water consumption (Marlow *et al.*, 2009). This shows that a plant-based diet can provide a significant water conservation benefit.

The numbers are in and we either act now or our numbers are up!

To find out why a vegan diet is best for health, go to www.vivahealth.org.uk

A Mad Max-future

If the warnings are ignored, food-related climate change will lead to a whole new range of health risks, the like of which we have never seen before…

"Particular policy attention should be paid to the health risks posed by the rapid worldwide growth in meat consumption, both by exacerbating climate change and by directly contributing to certain diseases" **(McMichael *et al.*, 2007).**

In addition to the large number of diseases meat and dairy are linked to, new health risks will emerge from physical hazards, temperature extremes, effects on air quality, altered patterns of transmission of infectious diseases and effects on food yields (McMichael *et al.*, 2007).

Professor Anthony J. McMichael warns: "*The broad health-risk categories of undernutrition and starvation, infectious disease outbreaks, and conflict and warfare are the most accessible for historical study in relation to climate*." (McMichael, 2012). These four catastrophic scenarios sound like a biblical disaster relating to the Four Horsemen of the Apocalypse: famine, pestilence, conquest and warfare!

Population displacement and conflict are likely, because of food insecurity, desertification, sea-levels rising and increased extreme weather events (Butler *et al.*, 2006). This may sound like science fiction but some scientists say we could be heading towards a situation resembling the world ravaged by drought and hardship seen in the futuristic film "*Mad Max: Fury Road*" if we don't act soon to curb climate change.

"The urgent task of curtailing global greenhouse gas emissions necessitates action on all major fronts" **(McMichael *et al.*, 2007).**

The food you eat is even more important than what kind of car you drive when it comes to global warming. The meat industry says it's unrealistic to expect people to stop eating meat, but scientists say it is not impossible to imagine a future world in which the consumption of meat is rare. We need to challenge these barriers and ask why changing the diet has not been a main issue on the climate agenda until now (Carlsson-Kanyama and González, 2009).

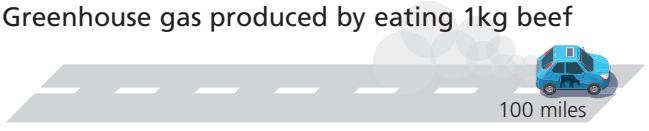
Change has been a long time coming and we simply can't afford to wait any longer.

The carbon footprint of food

The carbon footprint of food is a measure of all the greenhouse gases related to the production of that particular food. That includes growing, farming, processing, transporting, storing, cooking and disposing of food. Clearly the types of food you eat are a major influence on your personal carbon footprint.

The 'greenhouse gas potential' of different foods differs substantially when the total emissions for that food are calculated from farm to table. A study of 20 common foods consumed in Sweden (including carrots, soya beans, milk, pasta, pork, cheese and beef), shows over a 70-fold difference between beef and carrots and a 12-fold difference between cheese and soya beans – even after the soya beans were imported (Carlsson-Kanyama and González, 2009).

Greenhouse gas produced by eating 1kg beef



Greenhouse gas produced by eating 1kg soya beans

FOOD	KG CO_2E PER KG
Sheep and goat meat	14.61
Beef	12.14 and 32.00*
Fish (unspecified)	5.36
Pork	4.45
Turkey	3.76
Eggs	2.94
Chicken	2.84
Cow's milk	1.19
Lentils	1.06*
Avocado	0.88*
Nuts (miscellaneous)	0.88*
Chick peas	0.80
Wheat	0.52
Oats	0.38
Carrots	0.35
Apples	0.32
Peas	0.29
Potatoes	0.26
Cabbage	0.22

Greenhouse gas emissions (CO_2e per kg) from the production of foods for UK consumption.
*imported figures
Source: Audsley *et al.*, 2009.

Vegetables, cereals and pulses present the lowest greenhouse gas emissions (except some of those transported by airplanes). Animal products, including dairy, contribute considerably higher levels of emissions, with the highest emissions occurring in meats from ruminants with beef topping the list.

"Beef is the least efficient way to produce protein, less efficient than vegetables that are not recognised for their high protein content, such as green beans or carrots" **(Carlsson-Kanyama and González, 2009).**

- **Eating 1 kg of beef produces the same amount of greenhouse gas as driving 100 miles in a car while 1 kg of soya beans is the same as driving just three miles (Carlsson-Kanyama and González, 2009).**
- **One kg of UK-reared beef is associated with around 20 times more emissions than 1 kg of wheat (16 kg CO_2e compared to just 0.8 kg CO_2e) (Garnett, 2009).**

The most climate-friendly way to eat protein is to eat a mixture of wholegrains, pulses, nuts and seeds. Fish are not the answer as fish stocks are under severe threat with many stocks being over- or fully-exploited (FAO, 2016).

A study from German consumer protection organisation Foodwatch, found that meat-eaters' diets are responsible for almost twice the emissions as vegetarians' and **going vegan could cut your emissions more than seven-fold** (Foodwatch, 2008).

What a difference a diet makes

A vegan diet is the only truly 'green' diet, it is associated with lower greenhouse gas emissions than that of a meat-eater, fish-eater or a vegetarian.

The food you choose to eat has a significant impact on your carbon footprint. Eating only locally grown food for a whole year could save the greenhouse equivalent of driving 1,000 miles, while eating a vegetarian meal on just one day a week for a year could save the equivalent of driving 1,160 miles (Weber *et al.*, 2008).

Dr Peter Scarborough and colleagues at the University of Oxford found that going vegan could halve greenhouse gas emissions from food.

Their study found that emissions (in kg CO_2e per day) were 7.19 for people eating 100 grams or more of meat per day (many people eat twice that amount of meat every day!), 3.91 for fish-eaters, 3.81 for vegetarians and 2.89 for vegans (Scarborough *et al.*, 2014). According to the Food and Agriculture Organization Corporate Statistical Database, in 2013, the average person in the UK ate 223g of meat per day (FAOSTAT, 2017).

Lukasz Aleksandrowicz, a researcher from the London School of Hygiene and Tropical Medicine, reviewed 63 studies quantifying the effect of switching from a traditional Western diet to ones containing less meat. He found that you can reduce your personal emissions and land use footprint by 70-80% and water consumption by 50% just by adopting sustainable dietary patterns (Aleksandrowicz *et al*., 2016). This simple change could have a substantial impact – a diet for the future of the planet.

"…vegan diets having greater reductions in greenhouse emissions than vegetarian; greater benefits from reducing meat and dairy consumption compared to meat alone; and replacing meat with dairy having little benefit" (Aleksandrowicz *et al.*, 2016).

The average American diet produces an extra ton and a half of CO_2e (in the form of CO_2, methane, nitrous oxide and other greenhouse gases) every year compared to a vegetarian diet (Eshel and Martin, 2005). A vegan diet would produce even less. Gidon Eshel, Assistant Professor in Geophysical Sciences at the University of Chicago says: ***"…however close you can be to a vegan diet and further from the mean [average] American diet, the better you are for the planet"*** (University of Chicago News Office, 2006).

We do need to stop wasting food too. In 2007, the global carbon footprint of food waste was estimated at 3.3 Gtonnes of CO_2e (and that is without taking the land use change into account to produce this food). **So if food waste was a country, it would be the third top emitter, after the US and China, producing more than twice the total emissions of all US road transportation in 2010** (FAO, 2013).

Avoiding food grown in hot-houses or air-freighted to the UK could reduce your emissions by 5%, cutting out all avoidable food waste could cut them by 12%, switching to less intensive meats (from lamb and beef to pork and chicken) by 18% but eliminating meat from the diet reduces food-related greenhouse gas emissions by 35% (Hoolohan *et al.*, 2013).

Unless the demand for animal foods is drastically reduced, it seems unlikely that we will be able to meet the ambitious target set by the 2008 Climate Change Act of reducing greenhouse gas emissions to 80% lower than those in 1990, by 2050.

There is an urgent need to limit global warming while providing healthy and sustainably produced food for a growing population. Agriculture contributes greatly to climate change, with animal foods playing the major role in greenhouse gas emissions. The so-called diseases of affluence (obesity, heart disease, diabetes and some cancers) are reaching epidemic proportions mainly through lack of exercise and poor diet – inadequate intakes of plant foods and high consumption meat and dairy foods. Rising temperatures will reduce food yields and sea level rises resulting from polar ice sheets melting will lead to population displacement. Food security will likely become the major threat to humans on earth. For the first time in the history of dietary guidance, food and climate change are crossing paths to promote a sustainable, healthy diet (Meyer and Reguant-Closa, 2017).

Considering the high contribution of agriculture to man-made greenhouse gas emissions – your choice of food can be a problem or part of a solution in addressing climate change (Bauer *et al*., 2016).

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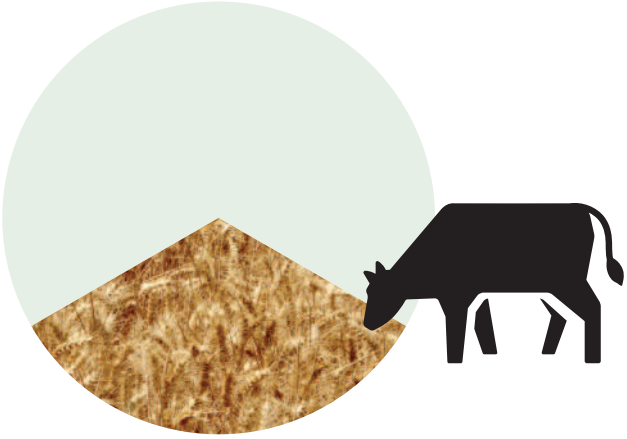
Land use

"Provision of food is a prerequisite for the functioning of human society"
(Kastner *et al*., 2012).

It's striking how small the actual amount of food that reaches people is, compared to the amount of food produced. The discrepancy is due to the inefficiency of producing animal foods.

A third of the world's cereal harvest is fed to livestock (Government Office for Science, 2011). Meat and dairy contain only a fraction (about 2.6%) of the feed and pasture biomass fed to livestock; the remainder is lost in metabolic processes, bones, cartilage, offal and faeces. This shows the energy inefficiency and the land-intensiveness of animal foods (Bajželj *et al.*, 2014).



An astonishing 75% of the world's agricultural land is used for raising animals – this includes croplands for animal feed, pasture and grazing (Foley *et al.*, 2011). Using croplands to produce animal feed – no matter how efficiently – represents a net drain on the world's food supply (Foley *et al.*, 2011).

From 1961 to 2011, 65% of the new land that was acquired for agriculture was used for the production of animal foods (Alexander *et al*., 2015). Considering the vast areas of pastures and grasslands used for livestock grazing, the actual land requirements for animal food production are massive. Some of this land may be lower quality than cropland but immense in size. So, meat and other animal foods are at the centre of discussions on food security and how we me might go about improving how we use the world's limited resources (Kastner *et al.*, 2012).

Current trends in improving crop yields will not be enough to meet global food demand in the future without substantially expanding agricultural land even further. By 2050, the world's population will reach 9.1 billion, 34% higher than in 2014. Just satisfying expected human food and animal feed demands will require increasing global food production by 70% (van Dooren *et al.*, 2014).

We are running out of space to grow food. Intensification with increased resource use will not produce enough to meet demand. We need to find a different way to achieve global food security without expanding crop or pastureland and without increasing greenhouse gas emissions (Bajželj *et al.*, 2014).

Five to 13% of the environmental impact of diet is due to land use (Baroni *et al*., 2007).

Increasing populations are placing unprecedented demands on agriculture and natural resources. Around a billion people are chronically malnourished while our agricultural systems continue to degrade land, water, biodiversity and climate on a global scale (Foley *et al.*, 2011).

Europe can grow enough vegetable protein to feed all its people, but not all its farmed animals. Only 20% of the protein fed to animals in Europe originates in Europe, the rest is imported from other countries, including developing ones, which plays an important role in the further impoverishment of these countries and the exploitation of their environmental resources (Baroni *et al.*, 2007).

Changing land use for livestock production is directly linked to deforestation. For the UK, when land use change emissions are considered, about a half the food chain emissions arise outside the UK. So, **where your food comes from matters**.

Global land use change emissions account for 40% of the emissions embedded in food consumed in the UK. Deforestation is a large source of emissions and expansion of agriculture is the biggest driver (Audsley *et al.*, 2009). The world's limited resources simply cannot keep pace with our hunger for animal foods.

Replacing fossil fuels in food production with biofuels is not the answer to reducing the environmental impact of food, as biofuel production adds significantly to land use. If all fossil fuels used in food production were replaced by biofuels, it would mean land use for food production would have to increase by 25% (Bryngelsson *et al.,* 2016).

The amount of land required by different foods varies widely, with animal foods requiring by far the most. Overall, the pattern for land use associated with different types of diet is similar to that for greenhouse gas emissions, with lower-emitting diets having lower land use and *vice versa*. This is because feed conversion efficiencies, which largely influence greenhouse gas emissions, are also closely linked to land use (Bryngelsson *et al.,* 2016). **The amount of land required by one meat-eater could be used to feed many vegans.**

One study found that vegetables and meat substitutes require less than 10m^2 per year for each kilogram of protein while meat from extensively farmed ruminants requires over 2000m^2 per year (Nijdam *et al.*, 2012). The combined results from a number of studies show the land use required by different foods:

Food	Carbon footprint (kg CO_2e per kg)	Land use (m^2 per year per kg)
Beef	9-129	7-420
Pork	4-11	8-15
Poultry	2-6	5-8
Eggs	2-6	4-7
Mutton and lamb	10-150	20-33
Cheese	6-22	6-17
Vegan meat substitutes	1-2	2-3
Dried pulses	1-2	3-8

Source: Nijdam *et al.*, 2012

European dairy production uses around three times more arable land per kilogram of protein than vegetable protein (Bryngelsson *et al.,* 2016). The bucolic image of a contented cow chewing the cud in a pastoral setting is a myth. Most beef and dairy cows

have a very different experience in their miserable, short lives. The drive for ever-increasingly cheap meat ensures that. Globally, **grazing-based systems contribute very little to the human food supply, accounting for less than 1% of its total food energy** (Herrero *et al*., 2015).

One study compared the environmental impacts of a range of diets including vegan, vegetarian, pescatarian, replacing ruminant meat, following health guidelines, the Mediterranean diet and meat reduction. When ranked for sustainability, similar trends for land use and greenhouse emissions were seen for each individual diet but **the vegan diet produced the biggest reduction – 45% less land use and 51% less greenhouse gas emissions** (Aleksandrowicz *et al.*, 2016).

Effects of land use changes are starting to be included in estimates of greenhouse gas emissions and carbon footprints of food production. Their omission has previously led to serious underestimates, particularly for meat.

Animal foods are the main determinant of environmental impacts, specifically on land and water use, energy use, greenhouse gas emissions and climate change. The consequences of a radical shift towards a vegan diet would be positive: a substantial influence on climate change, a profitable decrease in energy use and water waste, a lessening of the impact of deforestation, a much more rational use of soil and a dramatic decrease in the amount of chemicals used in agriculture (Baroni *et al*., 2014).

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Overfishing

Overfishing occurs when more fish are caught than can be replaced through natural reproduction. It is unsustainable and has serious consequences for the balance of life in our oceans.

Although fish is not a popular food in the UK, it is one of the most traded food commodities worldwide, with more than half of fish exports originating in developing countries.

Commercial production of fish for human use occurs in two ways:

- **Capture fishing** involves catching fish from natural resources, like the sea, a river or a lake.
- **Aquaculture** is the cultivation or farming of fish and other aquatic animals under controlled conditions. It includes fish farming in salt water or fresh water.

In 2014, 93.4 million tonnes of fish were caught through capture fishing and 73.8 million tonnes by aquaculture (giving a total of 167.2 million tonnes). Around 21 million tonnes of that was used for non-food products, of which 76% was reduced to fishmeal and fish oil and the rest used for a variety of purposes including feeding in aquaculture (FAO, 2016).

So, fish are being pulled out of the sea to feed farmed fish and livestock! It just doesn't make sense. Every pound of farmed salmon consumes three pounds of wild-caught fish (Gross, 2008). World aquaculture production continues to grow, now providing more than half of all fish for human consumption (FAO, 2016).

Scotland is the largest producer of farmed Atlantic salmon in the EU, and the third largest global producer after Norway and Chile. According to industry statistics, 162,817 tonnes of salmon were produced in 2016 (Munro and Wallace, 2017). There are plans to double the size of Scotland's aquaculture sector by 2030 with production of fish potentially in the range of 300,000 to 400,000 tonnes per year (Scotland Food and Drink, 2016).

Fish farming is presented by the industry as a more sustainable alternative to catching wild fish. However, fish farms transmit disease and foul coastal waters with a long list of organic and chemical contaminants, including faeces that choke marine life with excess nutrients, surplus additive-laden feed, antibiotics, pesticides, toxic paints and disinfectants (Gross, 2008).

Climate change and rising ocean temperatures could be making Scottish fish farms more vulnerable to bacterial infections. In 2017, about 125,000 salmon (around 500

tonnes of fish) died due to a disease outbreak at two fish farms on the Isle of Lewis. Local people raised concerns about the smell of rotting fish. The BBC reported that Steve Bracken, from Marine Harvest, said: "The health issues we have at Loch Erisort are the result of a bacterial infection…" (BBC, 2017).

In short, fish farming has negative impacts on wild fish and relies on fish feed that is based on fish meal and oil from wild fish. It is not the answer.
In 2014 global fish supply reached a new high of 20 kilograms per person per year (FAO, 2016).

The percentage of fish stocks overfished has steadily increased from 10% in 1974, to 26% in 1989 and 31.4% in 2013 (FAO, 2016). In 2012, 68% of fisheries (representing 78% of the global reported fish catch) failed to meet sustainable targets (Costello *et al.*, 2016) compared to 63% in 2006 (Worm *et al.*, 2009). Of course, that was just the 'reported' fish catch. Illicit fishing may account for up to 26 million tonnes of fish a year – more than 15% of the world's total (FAO, 2016).

Even more concerning is the finding that only **35% of stocks are currently fished at a level that would allow for recovery**. This means that most overfished stocks will experience further depletion and may face collapse (when catches drop below 10% of the recorded maximum). The number of fisheries collapsing has been accelerating over time, if trends continue, **88% of stocks will be overfished by 2050** (Worm, 2016).

Professor Boris Worm, marine research ecologist at Dalhousie University in Nova Scotia, Canada, says: "*Without a doubt, global fisheries are in for a hard landing if nothing changes*" (Worm, 2016).

Since the mid-1990s, the UN Food and Agriculture Organisation publishes a report called State of World Fisheries and Aquaculture (SOFIA) which analyses major trends. This report is used widely by policy makers and academics. They claim that marine catches have been more or less stable since the 1990s giving the impression that fisheries may be recovering.

However, some scientists claim that inaccurate fisheries statistics are masking the rapid decline in numbers of fish in the sea. Dr Dirk Zeller from the University of Western Australia and Dr Daniel Pauly from the University of British Columbia, believe that the poor quality of past recording and reporting methods have caused researchers to underestimate past fish catches by a substantial amount. They suggest that the idea that catches are now stable is incorrect and say far more fish were caught than previously reported and so the amount caught now actually reflects a huge drop (Pauly and Zeller, 2016; Pauly and Zeller, 2017). Probably because there are less fish in the sea!

Taken together, recent evidence shows that the overall trend is a decline in global fisheries, the extent of which remains to be seen.

Various government sanctions have been introduced including fishing quotas, bag limits, licensing, closed seasons, size limits and the creation of marine reserves and other marine protected areas. Each sanction comes with a set of inherent problems and overfishing continues.

In 2007 the South Pacific Regional Fisheries Management Organisation banned bottom trawling in the high seas areas it manages (accounting for about 25% of the global ocean). The North East Atlantic Fisheries Commission has also closed four seamounts and part of the mid-Atlantic ridge from all fishing. The Commission now has 15 Members from Asia, Europe, the Americas and Oceania:

- Australia
- Republic of Chile
- People's Republic of China
- Cook Islands
- Republic of Cuba
- Republic of Ecuador
- European Union
- Kingdom of Denmark in respect of the Faroe Islands
- Republic of Korea
- New Zealand
- Republic of Peru
- Russian Federation
- Chinese Taipei
- The United States of America
- Republic of Vanuatu

Source: SPRFMO, 2017.

Australia, Brazil, Canada, Malaysia and China, have established no-trawl zones. Hong Kong is one of the very few places to ban the practice completely, joining Indonesia, Palau and Belize.

In 2016, the European Parliament, Council of Ministers and European Commission agreed key provisions for a new EU regulation on deep-sea fishing that includes a

ban on bottom trawling below 800 meters in EU waters and establishes an obligation and procedures to close deep-sea areas to bottom fishing where vulnerable marine ecosystems are known or likely to occur.

Some other countries regulate bottom trawling but can only do so within their jurisdictions. More than 50% of the global ocean lies in areas beyond national jurisdiction, so the vast majority of international waters remain unprotected.

Bottom trawling is the world's most destructive type of fishing.

In international waters (beyond the 200 mile exclusive zones of coastal countries), many fisheries are unregulated and fishing fleets plunder the depths with state-of-the-art technology. In a few hours, **massive nets dragged along the bottom by deep-water trawlers (bottom trawling), can destroy deep-sea corals and sponge beds that have taken centuries or millennia to grow**. Some corals even resemble trees, growing up to 10 m (33 feet) in height. They have been discovered as deep as 3.5 kilometers (2.2 miles) and are often regarded as the rainforests of the sea.

Murray Roberts of the Scottish Association for Marine Science said "*In some places skippers have replaced their nets with chains, to take out the corals so they don't tear the nets. Then they go back and scoop up the fish*".

The vast majority of marine animal species live in, on, or immediately above the seafloor, and bottom trawling causes terrible damage to seafloor ecosystems and even more terrible damage to the fragile and slow growing ecosystems of the deep sea. The United Nations Environment Programme (UNEP) report *Cold-water Coral Reefs: Out of Sight, No Longer out of Mind* says: "*Undoubtedly, the greatest and most irreversible damage is due to the increasing intensity of deep-water trawling that relies on the deployment of heavy gear which 'steamrollers' over the sea floor*" (UNEP, 2004).

Some living corals may date back 1800 years and reefs may be older than the Egyptian pyramids. We are losing climate records, contained in corals, of the past centuries. Roberts says *"If we lose them, we are erasing invaluable historical records and we are not only losing our past – on one coral mound off Ireland we found eight species new to science in just a few samples. These are real biodiversity hotspots"* (MCBI, 2007).

There's a danger to human health too, deep ocean sediments are the sink for many toxic persistent organic pollutants (POPs) which get stirred up by bottom trawling and may then enter the food chain. Some countries regulate bottom trawling within their jurisdictions, but it continues in many areas of the world where it is unregulated.

Photo©Naomi Blinick-Marine Photobank

There are clear and increasing signs that bottom trawling is causing unprecedented damage to some of the most vulnerable ecosystems on our planet. In 2004, a group of 1,136 scientists from 69 nations called for an immediate worldwide moratorium – a time-out – on deep-sea bottom trawling (dragging a huge fishing net along the sea floor) in the high seas. This historic demand showed unprecedented concern in marine research circles about the exploitation of poorly understood and extremely vulnerable environments. The number of signatures subsequently grew, reaching a total of 1,452 in 2006 (MCBI, 2006).

Scientists from the Future of Marine Animal Populations (FMAP) program say that **up to 90% of all large predatory fish such as cod, sharks, halibut, grouper, tuna, swordfish and marlin have been depleted** (Myers and Worm, 2003). Dr Ransom Myers, world-renowned American marine biologist and conservationist, said: *"Since 1950, with the onset of industrialised fisheries, we have rapidly reduced the resource base to less than 10% – not just in some areas, not just for some stocks, but for entire communities of these large fish species from the tropics to the poles."*

Longline fishing is a commercial fishing technique using a long line with baited hooks attached at intervals, hundreds or even thousands of baited hooks can hang from a single line. Longliners commonly target swordfish, tuna, halibut, sablefish and many other species. Japanese longlining has expanded globally and has been likened to a hole burning through paper. As the hole expands, the edge is where the fisheries concentrate until there is nowhere left to go.

Some species often go underreported or unrecorded in official catch statistics. Sharks are generally ignored or given a low priority in most fisheries due to their characterisation as 'bycatch' (not the target species) and relatively low value compared to other fish. Estimates of the total number of sharks traded annually worldwide range widely from 26 to 73 million. Fishery-independent estimates of the scale of shark catches worldwide indicate that **shark fin trade is three to four times higher than reported shark catches**, suggesting the numbers of sharks caught are close to or possibly exceeding the maximum sustainable yield levels (Clarke *et al.*, 2006).

Over a third of all fish and seafood caught is wasted. Around 8% of all fish caught globally are thrown back into the sea. In most cases they are dead, dying or badly injured – this is equivalent to three billion Atlantic salmon (FAO, 2017).

Photo © Naomi Blinick-Marine Photobank

Large animals play important roles in complex ecosystems. Studies show that that the decimation of great whales by industrial whaling from 1946 to 1979 caused their foremost predators, killer whales, to begin feeding more intensively on smaller marine mammals beginning with harbour seals (populations collapsed early 70's and 80's) then fur seals (mid 70's to 80's), sea lions (late 70's to 90's) and finally sea otters (90's to today). By the late 1990's low numbers of sea otters allowed an explosion of sea urchins which led to the decimation of kelp forests due to the sea urchins' over-grazing. So, commercial whaling in the North Pacific Ocean set off a complex ecological chain reaction beginning in the open ocean over 50 years ago and leading to the destruction of kelp forests on shallow coastal reefs (Springer et al., 2003). This study illustrates the devastating domino effect of commercial fishing.

The disproportionate threat to large-bodied marine animals poses a danger to ecosystems. These animals are critical to ecosystem function because of their position at the top of food webs, importance to nutrient cycling and because of their ability to disturb sediments. **This is unprecedented in the history of animal life and may disrupt ecosystems for millions of years to come** (Payne *et al.*, 2016).

Records over the past 1,000 years show a rapid decline of biodiversity in coastal ecosystems since the onset of industrialisation. Ecosystems with a rich biodiversity are more stable, showing lower rates of collapse and extinction of fish and invertebrates. Studies suggest that 'business as usual' would foreshadow serious threats to global food security, coastal water quality and ecosystem stability, affecting current and future generations for years to come (Worm *et al.*, 2006).

In 2015, The United Nations' Climate Change Conference (COP21) – which led to the Paris Agreement – highlighted the urgency of reversing the current trend of overexploitation and pollution to restore aquatic ecosystems (FAO, 2016).

We have our work cut out for us – stop eating fish and help our oceans become healthy again.

To find out why plant-based omega-3 oils are best for your health see Viva!Health's Fish Report at: www.vivahealth.org.uk/resources/scientific-reports/fish-report.

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Water

Water is a vital element for human life and human activity is closely linked to availability and quality of water. Unfortunately, water is a limited resource and climate change scientists are concerned that access to water may become increasingly scarce for many people as global warming occurs.

At least two-thirds of the world's population, over four billion people, already live with severe water scarcity for at least one month every year and 500 million people live in places where water consumption is double the amount replenished by rain, leaving them extremely vulnerable. Water shortages are one of the most dangerous challenges the world faces and the situation may be far worse than previously thought (Mekonnen and Hoekstra, 2016).

Low water levels occur in areas with high population density (including cities like London), or where there is a lot of irrigated agriculture (for example in the High Plains in the US). Both high population density and agriculture together contribute to shortages in areas in India, eastern China and the Nile delta. Large water consumption relative to water availability is causing levels of rivers and lakes to drop, with some lakes disappearing. The Colorado River in the western US and the Yellow River in North China are both now fully or nearly depleted before they reach the end of their course (Mekonnen and Hoekstra, 2016).

Livestock production represents an inefficient use of water, with most of the water consumed used to irrigate crops for cattle feed. When crops are transformed into animal foods, most of the protein and energy contained in the plant foods are wasted – used by the animals for metabolic processes and to build tissue like bones, cartilage, offal and faeces (Baroni *et al.*, 2007).

"The water footprint of any animal product is larger than the water footprint of crop products with equivalent nutritional value." (Mekonnen and Hoekstra, 2012).

Agriculture is the biggest user of water and consumption continues to rise as the global population grows and the demand for meat increases. **Livestock production is responsible for 70% of global freshwater consumption, whereas only 22% is used by industry and 8% for domestic purposes** (World Watch Institute, 2004). Experts say that the planet's freshwater reserves will not be sufficient to feed our descendants with the present Western diet. Nevertheless, demand for meat continues to rise in both developed and developing countries (Baroni *et al.*, 2007).

Water consumption represents the most dramatic environmental impact: it accounts for 41-46% of a diet's overall environmental impact (Baroni *et al.*, 2007).

The water footprint measures the amount of water used to produce goods and services. It can be measured for a single process, such as growing rice, for a product, such as a leather handbag, for the fuel we use in our car, or for an individual person or even an entire company. Animal foods have a much larger water footprint than plant foods with beef topping the table. Beef requires 28 times more land, 11 times more irrigation water and emits five times more greenhouse gas than pork, poultry, eggs, and dairy (Eshel *et al.*, 2014). From 1996 to 2005, beef production alone used a third of the entire water footprint of all farmed animals in the world (Mekonnen and Hoekstra, 2010; Mekonnen and Hoekstra 2012).

THE WATER FOOTPRINT OF SELECTED FOODS.

Food	Litres per kg
Beef	15,400
Sheep	10,400
Pig meat	5,990
Butter	5,550
Cheese	5,060
Chicken (broiler)	4,300
Eggs	3,300
Milk	1,020
Nuts	9,063
Pulses	4,055
Rice	2,500
Cereals	1,644
Maize	1,220
Vegetables	322
Potatoes	290

Source: (Mekonnen and Hoekstra, 2010; Mekonnen and Hoekstra 2012).

In terms of calories, the water footprint of animal products is larger than for crop products; water use per calorie for beef is 20 times larger than for cereals and starchy roots. The same applies to protein. The water footprint per gram of protein for milk, eggs and chicken is about 1.5 times larger than for pulses. For beef, the water footprint per gram of protein is six times larger than for pulses (Mekonnen and Hoekstra 2012).

Intensive livestock farming places a strain on scarce water resources and a global shift in diets away from livestock products could free significant amounts of water (Bailey *et al*., 2013). Halving the amount of animal products in the diet would reduce water consumption by 6% but cutting animals products out completely would reduce it by 21%. **Reducing animal products in the diet could save enough water for 1.8 billion people** (Jalava *et al.*, 2014).

Remember, four billion people live under conditions of severe water scarcity at least one month of the year and half a billion face severe water scarcity all year round (Mekonnen and Hoekstra, 2016). Is a burger really more important than the large number of people (typically women and girls) who have to walk for several hours every day to fetch safe water?

The United Nations' Food and Agriculture Organisation estimates that each year, approximately a third of all food produced for human consumption in the world is lost or wasted. This food wastage represents a missed opportunity to improve global food security, but also to mitigate environmental impacts and resources use from food production. Globally, the freshwater footprint of food waste is equivalent to three times the volume of Lake Geneva or the annual water discharge of the Volga River, the longest and largest river in Europe (FAO, 2013).

The politics of water

Studies show a direct link between climate change and conflict. Climate change contributed to the severe 2007-2010 drought (the worst on record) in Syria that led to mass migration of farming families into cities. The drought had a catalytic effect, contributing to political unrest. This shows a direct path leading from human interference with the climate to severe drought to agricultural collapse and mass human migration (Kelly *et al.*, 2015).

Yemen has fallen into a deep water crisis, partly due to the rapid mining of groundwater, extreme water supply shortages in cities and limited access to safe drinking water (Alyousefi *et al.*, 2011). Some reports say **Yemen could be the first country to run out of water!**

Many other places are living on borrowed time as groundwater is continuously depleted, including Pakistan, Iran, Mexico and Saudi Arabia.

In his Keynote Speech at the Stockholm Water Conference in 2000, Lester Russel Brown, environmental analyst, founder of the Worldwatch Institute and founder and former president of the Earth Policy Institute, said: ***"It is now commonly said that future wars in the Middle East are more likely to be fought over water than over oil"*** (Earth Policy Institute, 2000).

We've known about the dangers of water shortages for a long time. In 1992, The International Conference on Water and the Environment (ICWE) took place in Ireland leading to the Dublin Statement which stated: *"Scarcity and misuse of fresh water pose a serious and growing threat to sustainable development and protection of the environment. Human health and welfare, food security, industrial development and the ecosystems on which they depend, are all at risk, unless water and land resources are managed more effectively in the present decade and beyond than they have been in the past"* (ICWE, 1992).

If nothing is done, water shortages are set to worsen as population growth and increasing water use – particularly through eating meat – continues to rise. The World Economic Forum lists water crises as **the largest global risk of harm to people and economies over the next decade** (World Economic Forum, 2015).

We can change the way we use limited natural resources. A shift in eating habits towards a plant-based diet is the most desirable objective. A vegan diet could play an important role in preserving environmental resources and in reducing hunger and malnutrition in poorer nations (Baroni *et al*., 2007).

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Biodiversity

Arguably the most serious aspect of the environmental crisis is the loss of biodiversity – the other living things with which we share Earth (Ceballos *et al*., 2015).

Biodiversity refers to all terrestrial, marine and other aquatic species of plant and animal, the genetic diversity between them and the ecosystems they inhabit (FAO, 2018). It's short for 'biological diversity' and even includes microorganisms such as bacteria, viruses and fungi. In other words, biodiversity is the amazing variety of life on Earth.

Biodiversity is key to food security and nutrition (FAO, 2018).

So why does it matter? Some examples are obvious – without plants there would be no oxygen and without bees to pollinate plants there would be no fruit or nuts. We know that tress in the city can help combat pollution. Other examples are less obvious – large-fruit-eaters, such as tropical tortoises and spider monkeys, help maintain a stable climate by dispersing the seeds of the dense, hardwood trees that are most effective in removing carbon dioxide from the atmosphere.

"Without biodiversity, there is no future for humanity" says David Macdonald, Professor of Wildlife Conservation and Director of the Wildlife Conservation Research Unit at Oxford University.

How dependent one part of a complex ecosystem is on another may not be apparent until it is lost. Think of biodiversity like a knitted jumper – pulling out a lose thread may not cause a serious problem or it may unravel the entire jumper.

Habitat degradation and land use change are among the major factors causing biodiversity loss and livestock farming is at the heart of this environmental catastrophe.

Species-rich habitats are being converted to pasture and feed crops for livestock as the human appetite for meat grows. As forests, woodlands, hills and savannas are taken over, either for grazing or for growing animal feed crops, native plant and animal species and their habitats are being lost at an unprecedented rate.

A study published in the *Science of the Total Environment* shows how livestock production is pushing pastures and cropland into areas of high biodiversity. Many of the places seeing the greatest shift in land use, from forest to livestock, are in countries with the largest number of species. By 2050, given current trends, these countries will likely increase the land used for livestock by 30-50% (Machovina *et al*., 2015). This study provides a direct link between livestock farming and loss of biodiversity.

Over the last 50 years or so, an increasingly small numbers of plant and animal species have been selected for uniformity and suitability to intensive farming methods – global food production is now

dominated by just a handful of species. In other words, most of the food we eat comes from a limited number of plants and animal species which are being farmed in in huge monocultures and mega farms.

Three quarters of the world's food is generated from just 12 plant and five animal species (FAO, 2004).

The global chicken population is now almost 22 billion – more than three chickens for every single person. If you weighed the global cattle population, that too would be greater than the weight of all humans (Bailey *et al*., 2014). At current levels of consumption, such massive livestock populations have profound consequences for biodiversity because of deforestation, change of land use, overgrazing, degradation of grasslands and desertification (Bailey *et al*., 2014).

The environmental impact of meat and dairy products far exceeds that of plant-based foods – meat, fish, eggs and dairy use around 83% of the world's farmland and contribute 56-58% of food's different emissions but only provide 37% of the protein we eat and 18% of calories (Poore and Nemecek, 2018). The human appetite for meat and dairy products comes at a high price.

The global demand for animal foods is expected to increase substantially, driven by a growing global population, increased prosperity and a shift in dietary patterns. If trends continue, greenhouse gas and nitrogen emissions from livestock farming will rise and cropland and grassland areas could expand by 10-20% over the coming decades, leading to significant losses of biodiversity, especially in South Asia, Sub-Saharan Africa and South America (Westhoek et al., 2011).

Researchers writing in the journal *Trends in Ecology and Evolution* issued a stark warning when they described what is happening in our rainforests. Characterised by uniquely dark, humid and stable microclimates, rainforests sustain many species suited to the interior of the forest that shy away from the forest edges and are unable to cross clearings. Large numbers of beetles, flies, ants, bees, butterflies, amphibians, reptiles, birds, bats, small and large mammals avoid even narrow clearings. New roads, highways, power lines and gas lines are rapidly expanding in tropical forests and can increase habitat fragmentation, road kill, hunting (bush-meat harvesting) as well as forest fires.

These clearings also enable species invasion, of for example, fire ants, earthworms, non-forest vertebrates and various weeds. Little fire ants spreading through African rainforests 60 times faster along logging roads than through undisturbed forest can kill or blind native species such as monkey, apes, leopards and insects. The authors of this study warn: *"As Pandora quickly learned, it was much harder to thrust the evils of the world back into the box, than to simply not open it in the first place"* (Laurance *et al*., 2009).

Wilderness (uncultivated) areas tend to contain the richest levels of biodiversity. However, the Earth's wilderness areas are disappearing at a faster rate than attempts to protect them can keep pace with. Catastrophic declines in wilderness areas around the

world have occurred in recent years. Around 20% (30.1 million km2) of the world's land area is wilderness, mostly in North America, North Asia, North Africa and the Australian continent. Since the 1990s, 10% (3.3 million km2) of this wilderness land has been lost – an area twice the size of Alaska and half the size of the Amazon (Watson *et al*., 2016).

Between 1993 and 2009, the extent of Earth's wilderness areas has been reduced by 30% in South America, 14% in Africa and 10% globally (Watson et al., 2016).

Dr James Watson, of the University of Queensland in Australia and the Wildlife Conservation Society in New York, says: *"If we don't act soon, there will only be tiny remnants of wilderness around the planet, and this is a disaster for conservation, for climate change, and for some of the most vulnerable human communities on the planet".*

For decades scientists have been warning that human activity is pushing life on our shared planet toward a sixth mass extinction. **Natural ecosystems are degrading at a rate unprecedented in human history.**

Every two years, the World Wide Fund for Nature (WWF) publishes its *Living Planet* report providing information on which habitats and ecosystems are declining most rapidly. The 2016 edition says: *"Wildlife populations have already shown a concerning decline, on average by 58 per cent since 1970 and are likely to reach 67 per cent by the end of the decade"* (WWF, 2016).

In terms of biodiversity loss, most attention is focused on rainforests. Savannahs and grasslands (grassy biomes) are considered poor cousins of the tropical rainforest. However, in areas of high rainfall, the diversity of vertebrates in grassy biomes can be just as high as in rainforests. These biomes should be recognised as a critical, but increasingly threatened, store of global biodiversity (Murphy *et al*., 2016).

In Britain, at least one in five wild mammals faces a high risk of extinction within a decade and overall populations are falling. Most at risk are the Scottish wildcat and black rat (which may already be extinct). In 2018, there was only a single male greater mouse-eared bat left who was last seen living alone in a railway tunnel in West Sussex. Other species at risk include hedgehogs, rabbits and water voles. The most numerous species is the field vole at 60 million, followed by the mole, at 41 million. Both are outnumbered by livestock, with 44 million sheep and cattle (combined) and 181 million chickens (Mathews *et al*., 2018).

Switching from meat to fish is not the answer. Biodiversity loss on land is linked to livestock production and its contribution to desertification, overgrazing and degradation of grasslands, deforestation and change of land use. However, livestock production also leads to substantial emissions of nitrogen in various forms (ammonia, nitrates), which in turn lead to losses of both land and aquatic (including marine) biodiversity.

Marine and freshwater biodiversity is under threat and wild fish stocks are in decline. Globally, marine fish populations have declined by 24% since 1950. About 80% of commercial fish populations are fully exploited or overexploited (that means close to its maximum sustainable yield or over it respectively). In the same way that increasing meat production is harming biodiversity of land animals and plants, increasing fish consumption would have an unfavourable impact on marine biodiversity (Westhoek *et al*., 2011).

Marine species (seabirds, marine mammals, sea turtles and fish) have declined by 36% between 1970 and 2012 with an average decline of 1% per year (WWF, 2016).

The European Council in March 2010 agreed on *"a headline target of halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss"* (Westhoek *et al*., 2011). However, if current trends continue, targets will be increasingly difficult to meet. The WWF says that we are already off track for reaching UN biodiversity targets aiming to halt the loss of biodiversity by 2020 (WWF, 2016).

Losses of habitats and species extinction are taking place at an alarming rate: up to 100,000 species go extinct every year (WWF, 2015).

It's hard to estimate precisely how many species are being lost as we don't know exactly what's out there – new species are being discovered all the time. If the upper estimate of species numbers is true (that there are 100 million different species co-existing with us on our planet) then between 10,000 and 100,000 species are becoming extinct each year (WWF, 2015).

The International Union for Conservation of Nature (IUCN) Red List of Threatened Species is the world's most comprehensive inventory of the global status of plant and animal species. Species are classified as: extinct, extinct in the wild, critically endangered, endangered, vulnerable, near threatened, least concern, data deficient and not evaluated.

Currently there are over 79,800 species on the IUCN Red List, of which more than 23,000 are threatened with extinction, including 41% of amphibians, 34% of conifers, 33% of reef building corals, 25% of mammals and 13% of birds (IUCN, 2017). The basic message is that, whatever the threat category or species group, overexploitation and agriculture have the greatest current impact on biodiversity (Maxwell *et al*., 2016).

Of all the plant, amphibian, reptile, bird and mammal species that have gone extinct since AD 1500, 75% were harmed by overexploitation or agricultural activity or both (Maxwell *et al*., 2016).

Writing in the journal *Nature*, a team from the University of Queensland, the Wildlife Conservation Society and the IUCN assessed 8,688 near-threatened or threatened species on the IUCN's 'red list' against 11 threats: overexploitation, agricultural activity, urban development, invasion and disease, pollution, ecosystem modification, climate change, human disturbance, transport and energy production.

Most of the species looked at were affected by more than one threat. However, they found that **overexploitation and agricultural activity were by far the most prevalent threats facing these threatened or near-threatened species** (Maxwell *et al*., 2016).

They said the expansion of agriculture is threatening 5,407 species (62% of those listed as threatened or near-threatened). Africa's cheetah, Asia's hairy-nosed otter and South America's huemul deer were among more than 2,300 species affected by livestock farming and aquaculture. The Fresno kangaroo rat and the African wild dog are two of more than 4,600 species under threat from land use changes associated with the production of food, animal feed or biofuels (Maxwell *et al*., 2016).

Climate changes (increases in storms, flooding, extreme temperatures, drought and sea-level rise) affected 19% of species listed as threatened or near-threatened. Hooded seals were among the 1,688 species affected and have dropped in abundance by 90% in the North-eastern Atlantic Arctic over the past few decades (Maxwell *et al*., 2016).

The IUCN Red List of Threatened Species was key in informing a landmark new report from the United Nations Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). The report found that around **one million animal and plant species are now threatened with extinction, many within decades, more than ever before in human history** (United Nations, 2019).

"Nature is declining globally at rates unprecedented in human history – and the rate of species extinctions is accelerating, with grave impacts on people around the world now likely" (United Nations, 2019).

The UN report was compiled by 145 expert authors from 50 countries over three years, with inputs from another 310 contributing authors. It assessed changes over the past five decades and offers a range of possible scenarios for the coming decades saying it is not too late to make a difference, but only if we start now at every level from local to global. Through 'transformative change' the report says, nature can still be conserved, restored and used sustainably.

Mass extinction

Scientists describe mass extinctions as times when the Earth loses more than three-quarters of its species in a geologically short interval. This has happened only five times in the past 540 million years or so. Biologists now suggest that a sixth mass extinction may be under way, given the known species losses over the past few centuries and millennia (Barnosky *et al*., 2011).

Writing in the *Proceedings of the National Academy of Sciences*, scientists investigated nearly half of all known vertebrate species and found that 32% (8,851 out of 27,600) had decreased in population size and range. In the 177 mammals they had detailed information for, all had lost 30% or more of their geographic ranges and more than 40% had experienced severe population declines. They said that Earth is experiencing a huge episode of population declines, which will have negative cascading consequences on ecosystem functioning and services vital to sustaining civilisation. They describe this as a 'biological annihilation' to highlight the current magnitude of Earth's ongoing sixth major extinction event (Ceballos *et al*., 2017).

Meat – the challenge

Our global society has started to destroy species of other organisms at an accelerating rate, initiating a mass extinction episode unparalleled for 65 million years (Ceballos *et al*., 2017).

Climate change will become an increasingly dominant problem in the biodiversity crisis, but human development and population growth mean that the impacts of overexploitation and agricultural expansion will also increase (Maxwell *et al*., 2016).

The human consumption of animal foods is one of the most powerful negative forces affecting the conservation of terrestrial ecosystems and biological diversity. Livestock production is the single largest driver of habitat loss and both livestock and feed crop production are increasing in developing tropical countries, where the majority of biological diversity resides (Machovina *et al*., 2015).

The loss of biological diversity is one of the most severe human-caused global environmental problems (Ceballos *et al*., 2017).

Scientists say that an exceptionally rapid loss of biodiversity over the last few centuries indicates that a sixth mass extinction is already under way. *"Averting a dramatic decay of biodiversity and the subsequent loss of ecosystem services is still possible through intensified conservation efforts, but that window of opportunity is rapidly closing"* (Ceballos *et al*., 2015).

Human consumption of animal foods inevitably impacts the environment, but there is much scope for increasing global food availability in such a way that halts impacts on biodiversity. The devastating impact livestock farming is having on the world's rich biodiversity can be stopped through the widespread adoption of a vegan diet.

"A vegan diet is probably the single biggest way to reduce your impact on planet Earth, not just greenhouse gases, but global acidification, eutrophication, land use and water use" says Joseph Poore, researcher at the University of Oxford (Carrington, 2018).

Ecological roulette

We know that biodiversity loss affects ecosystem function, but how it does is not entirely clear, we are gambling with very high stakes. Ignoring the devastating impact livestock farming is having on biodiversity has been likened by some scientists to playing a game of ecological roulette. Government support for a radical change in recommended diets is long-overdue and the need for action has never been so urgent.

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Deforestation

Beef production is the world's biggest driver of tropical deforestation.

Trees (and other plants) absorb CO_2 from the air. During photosynthesis they use energy from the sun to turn the carbon from CO_2 into building blocks for their trunks, branches and foliage and they release oxygen back into the atmosphere. If you take away the trees, you end up with more CO_2 in the atmosphere. For this reason, deforestation is the second largest contributor of CO_2 in the atmosphere after fossil fuel combustion.

"Forests store more carbon than any other land-cover type per unit area" **(Saugier *et al.*, 2001).**

People have been converting forests into agricultural land for thousands of years as populations and the demand for food grows. From 1750 until the late 19th century, most land use changes involved deforestation in temperate regions (between the tropics and the Polar Regions where the temperatures are relatively moderate). Temperate means moderate and in these regions, the average yearly temperatures are not extreme – neither really hot nor freezing cold. Here, forests and woodlands were cleared to make room for fields and pastures.

For many years now, deforestation has been greatest in the tropics (where the temperature remains relatively hot throughout the year). During the 1980s and 1990s, rainforests became the primary source for new agricultural land with more than 80% coming from both intact and disturbed forests (Gibbs *et al.*, 2010). It is now predicted that the forested area in the Amazon could be halved by 2050 (Longobardi *et al.*, 2016).

In the tropics, from 2000 to 2010, around seven million hectares of forest were lost and more than six million hectares of agricultural land gained (FAO, 2016). One hectare is about the size of a European football field or Trafalgar Square in London – imagine seven million!

The largest loss of forest and largest gain in agricultural land occurred in low-income countries. In Central and South America, sub-Saharan Africa and South and Southeast Asia, forest loss was associated with increasing rural populations (FAO, 2016).

In tropical and subtropical countries, large-scale commercial agriculture and subsistence agriculture account for over 70% of deforestation. In Latin America, commercial agriculture accounts for almost

70% of deforestation but in Africa, it accounts for only one third, where small-scale agriculture is a more significant driver (FAO, 2016).

In 2007, the IPCC estimated that deforestation accounted for 17% of global greenhouse gas emissions (IPCC, 2007). Two years later, in a paper published in *Nature Geoscience*, it was argued that the figure was actually closer to 12% (Van Der Werf *et al.*, 2009). However, while the rate of deforestation has remained fairly constant, emissions from burning fossil fuels are increasing rapidly. It therefore follows that the percentage of emissions from deforestation might appear to be dropping even though we are still slashing and burning our way through the rainforests.

The global rate of deforestation may have slowed in the last decade, but it remains alarmingly high in many parts of the world. In Europe, North America and Northeast Asia, gains in forest land have been achieved along with a reduction in agricultural land. However, imports of animal foods have increased so we have simply moved the problem elsewhere. This is known as 'carbon leakage' as it does not reduce global emissions.

Brazil is the world's second largest beef producer and the world's top beef exporter, with exports having increased seven-fold during the past decade (Cederberg *et al.*, 2011).

The effects of land use changes are starting to be included in estimates of greenhouse gas emissions and carbon footprints from food production. Their omission has led to serious underestimates, particularly for meat. One study estimated emissions from the conversion of forest to pasture in the area of the Amazon Basin known as Amazônia Legal (Legal Amazon). Expansion of cattle ranching for beef production is a major cause of deforestation in this region. The carbon footprint of beef produced on newly deforested land was estimated at more than 700 kg CO_2 equivalents per kg of carcass weight. This is considerably higher than other carbon footprint estimates for beef.

Increased production for export has been the key driver of the pasture expansion and deforestation in this region during the past decade and this should be reflected in the carbon footprint attributed to beef exports. **Carbon footprints must include the effects of land use changes to avoid giving misleading information to policy makers, retailers and consumers** (Cederberg *et al.*, 2011).

Land-clearing methods such as slash-and-burn compound these effects by directly releasing greenhouse gases into the air. Slash-and-burn agriculture involves cutting and burning a forest to create a field. Widespread deforestation aided by fire has occurred in parts of the world where forests have been removed permanently for industrial-scale crop production. **Fire-driven deforestation is the main source of carbon emissions in the Amazon** (Marle *et al.*, 2017).

"…deforestation is not a precondition for supplying the world with sufficient food in terms of quantity and quality in 2050" **(Erb *et al*., 2016)**

There is widespread interest in better-understanding the greenhouse gas emissions and carbon footprint of different foods. The main purpose of estimating these is to provide information for policy-making, for supply chain management and to facilitate a shift by retailers and consumers toward low-carbon products (Cederberg, 2011).

How environmentally friendly is your beef burger?

Most of the soya grown on farms in Latin America is used for animal feed to fuel the supply of fast food consumed around the world. However, there is little traceability and the strong links between a burger eaten in London or Manchester for example and Amazonian deforestation are lost.

Early in 2017, the campaign groups Mighty Earth and Rainforest Foundation Norway released the *Mystery Meat* report showing how the hamburger chain, Burger King, was keeping the origins of its meat secret. Through remote sensing, supply chain investigation, drone videos and field visits to 29 plantations across 3,000 kilometres of jaguar and sloth habitat in Brazil and Bolivia, the report revealed Burger King and its suppliers' massive contribution to rainforest destruction (Bellantonio *et al.*, 2017). In response to the very public campaign, in June 2017, Burger King released new environmental commitments setting a goal of eliminating deforestation by 2030 (Restaurant Brands International, 2016). However, some environmental activists say this is nothing more than a marketing ploy – or 'greenwashing,' to build up an eco-friendly appearance.

The more animal products we eat, the more endangered our forests become. Changing the diet could have a phenomenal impact on world hunger and deforestation.

Researchers from the Institute of Social Ecology in Vienna published a study in *Nature Communications* revealing that it is possible to produce enough food for the world in 2050 while maintaining the current forests of the world – that means **zero deforestation**.

They looked at a range of dietary scenarios including diets rich in meat, reduced meat, vegetarian, vegan and organic diets. The only diet that worked was a vegan one and **if the world went vegan, in 2050 we would require less cropland than we did in 2000**. In other words, if the whole world becomes vegan, the projected global population in 2050 (nine billion) could eat enough without another single tree being cut down (Erb *et al*., 2016).

The Organisation for Economic Co-operation and Development (OECD) is an intergovernmental economic organisation with 35 member countries. Most OECD members are high-income economies regarded as developed countries. Modelling in the WWF's *Living Forests Report* suggests that meat consumption in OECD countries must be halved by 2050 if we are going to achieve zero deforestation and degradation (Taylor, 2011).

The greenhouse gas mitigation from dietary changes increases substantially if their land-saving effects are included. **If we all went vegan and the land used previously for animals was allowed to revert to forest, the resulting carbon sequestration in vegetation stocks (carbon being captured and held in plants and soil) could be large enough to cancel out 300 years of all food-related greenhouse gas emissions** (Bryngelsson *et al.*, 2016).

There is no question that global demand for animal foods will continue to rise unless we actively promote changing the diet. There is a clear need for a strategic, integrated approach to agriculture, forestry and other policies linked to how we use the planet's natural resources (FAO, 2016).

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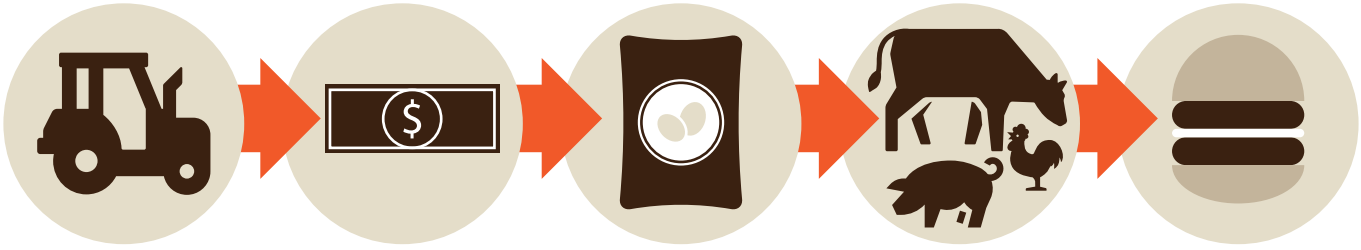
FOLLOWING SOYA ALONG A TRAIL OF DESTRUCTION THROUGH THE MEAT SUPPLY CHAIN



FARMERS | TRADERS | FEED PROCESSORS | MEAT PRODUCERS | CONSUMER COMPANIES

Antibiotic resistance

The routine overuse of antibiotics in livestock production has led to the rapid increase in antibiotic-resistant strains of bacteria known as 'superbugs'. The more bacteria are exposed to antibiotics, the more likely it is that superbugs will appear – this has become a major concern for human health, not confined to developing countries.

In 2017, the World Health Organisation (WHO) launched new guidelines on use of antibiotics in animals, recommending that farmers and the food industry stop using antibiotics routinely to promote growth and prevent disease in healthy animals. WHO says that "*In some countries, approximately 80% of total consumption of medically important antibiotics is in the animal sector, largely for growth promotion in healthy animals*".

"*A lack of effective antibiotics is as serious a security threat as a sudden and deadly disease outbreak*," says Dr Tedros Adhanom Ghebreyesus, Director-General of WHO. "*Strong, sustained action across all sectors is vital if we are to turn back the tide of antimicrobial resistance and keep the world safe.*"

There is evidence of a global rise in antibiotic-resistant bacteria due to the extensive and inappropriate use of antibiotics in animal production (Groot and Van't Hooft, 2016).

The quantity of antibiotics used in livestock is vast. In the US, for example, **70% of the antibiotics defined as medically important for humans are sold for use in animals.** Many countries are also likely to use more antibiotics in agriculture than in humans but don't publish the information (O'Neil, 2016).

Livestock are exposed to enormous quantities of antibiotics (despite attempts at reduction) and act as a reservoir of resistance genes (Woolhouse *et al.*, 2015). The presence of antibiotic-resistant bacteria on farms can lead to the contamination of meat and the transfer of superbugs from animals to humans. Plant foods (and so vegetarians and vegans) can also be affected via bacteria in manure contaminating crops, fruit and vegetables.

Pig and cow manure have been shown to increase the number of antibiotic-resistance genes in the soil for months or even years. Resistance genes in manure

represent an increased risk of crop contamination and an increased risk of human consumption of these genes (Marti *et al.*, 2014). Another concern is the presence of antibiotic-resistance genes in wastewater or run-off from livestock facilities (Berglund, 2015).

A 2015 government review found that antibiotic-resistant bacteria can be passed on to humans through **undercooked meat**. The report argues that **the case for reducing antibiotic use in agriculture is compelling and that there is a need to act now**. Of the 139 studies they looked at, 100 (72%) found evidence of a link between antibiotic consumption in animals and resistance in humans. They said we need to take urgent steps to make sure that the use of antibiotics in animals, which are also given to humans, is restricted or banned (O'Neill, 2015).

Antibiotic-resistant strains of bacteria are increasing at an alarming rate; of particular concern are the infamous multidrug-resistant *Staphylococcus aureus* (MRSA) which has emerged from pig farms and cephalosporin-resistant *E. coli* (G3CREC) originating from the overuse of antibiotics in broiler chicken farms. It was estimated that in the UK in 2007, there were 1,580 cases and 282 deaths associated with poultry-derived G3CREC (Collignon *et al.*, 2013).

Not long after antibiotics were first used widely in humans it was discovered that they could promote more rapid growth when given to farm animals at low levels (O'Neill, 2015). However, the use of antibiotics at low 'sub-therapeutic' levels encourages the development of resistant bacteria. **Despite a 2006 EU-wide ban on growth-promoting antibiotics added to animal feed, huge quantities of antibiotics continue to be given for 'disease prevention'.**

Livestock-associated methicillin-resistant *Staphylococcus aureus* (LA-MRSA CC398) is an important cause of animal-to-human infections in many countries. One study found this particular bug in retail meat samples from UK farms (Hadjirin *et al.*, 2015). They suggested that it was probably established in UK pig farms, demonstrating a potential pathway for the transmission of this type of MRSA from livestock to humans.

Another study looked at over 1,000 people living in Iowa, of whom around half worked in livestock farming. They found that people who worked with pigs were six times more likely to carry MRSA than those with no exposure to pigs. They tested a married couple where one had exposure to livestock but the other did not, both were carrying MRSA, suggesting one caught it from the other (Smith *et al.*, 2013).

Bacteria resistant to colistin (the strongest antibiotic and our last defence against multi-resistant bacteria) have recently emerged in pig farms. The resistance genes in these bugs can be passed between different types of bacteria – and can infect humans. This is a new development showing how **antibiotic use in animals is creating a major human health risk** (O'Neill, 2015). Screening of foods from areas in China where colistin is routinely given to pigs revealed a high number of resistant bacteria. They found colistin-resistant *E. coli* in more than 20% of animals, 15% of raw meat samples and 1% of hospital patients (Liu *et al.*, 2016).

The need to restrict or ban certain antibiotics in animals has never been so urgent. We are charging headlong towards a 'post-antibiotic era' where common infections in people are becoming untreatable, no longer responding to the antibiotics that we have been relying on for years (Lipsitch *et al.*, 2002).

Antibiotic resistance is somewhat analogous to climate change in that we are doing it to ourselves. An international group, like the Intergovernmental Panel on Climate Change (IPCC), could be an appropriate way to actively address the problem (Woolhouse *et al.*, 2015). Without policies to stop the spread of antibiotic-resistant bacteria, **by 2050, today's already large 700,000 deaths every year could become an extremely disturbing 10 million a year – more people than currently die from cancer** (O'Neill, 2016).

There is no question that intensive livestock production is associated with antibiotic resistance and increasing incidence of emerging diseases. Writing in the *American Journal of Clinical Nutrition*, Dr Harry Aiking, expert on global food security and food sustainability, said that a 'reversed' diet transition back to less animal protein could make a difference.

Aiking said: ***"…getting consumers to change their diets in a more sustainable direction is likely to require much more than gentle nudging. National governments and the United Nations should assume their responsibilities and initiate a global strategy integrating sustainability, food security, nutrition, and equity. To date, the profit pillar of sustainability has taken precedence over planet and people. It is time to redress the balance"*** (Aiking, 2014).

Antibiotic resistance is a problem of our own making, a direct consequence of the inappropriate use of antibiotics. Restrictions on antibiotic use in animals cannot always wait for incontrovertible evidence of harm and a delay may result in a lost opportunity to preserve the usefulness of certain antibiotics in human medicine (Smith *et al.*, 2002). Time is running out and we need to act now.

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Desertification

Desertification occurs when fertile land is transformed into desert. It is caused by a variety of factors including climate change and the overexploitation of soil through overgrazing and deforestation. It happens when land becomes increasingly arid as it loses water and vegetation which plays a vital role in maintaining land integrity.

Desertification is not the desert advancing and gaining ground – it is land that is overexploited, dry and no longer fertile *becoming* desert (Grainger *et al.*, 2002).

Dr Alan Grainger, Senior Lecturer in Global Change and Policy at the University of Leeds says that desertification is the Cinderella of global environmental change. It potentially affects 40% of the Earth's surface and 32% of the human population but compared to global climate change, receives relatively little attention.

Desertification caused by land use change usually follows a well-trodden path, starting with the removal of forest vegetation for subsistence farming, then grazing follows (Viglizzo and Frank, 2006). As cows graze, they tramp down the soil, this compacts it, making it hard for water to soak into the ground, which further prevents growth and development of any new forestation (Arnalds *et al*., 2004). If left unchecked, the earth dries as dust and sand replace fertile land. In recent years, more and more of the sandstorms that form in new desert areas have swept into modern cities in areas such as north-western China, Africa, the western US and Australia (Cyranoski, 2009).

Grassland ecosystems have been degraded by climate change, overgrazing and change of land use (Qi *et al.*, 2012).

Hyper arid, arid and semi-arid areas are collectively referred to as drylands and they occupy around 40% of Earth's land area (Reynolds *et al.*, 2007). Half the land in China is made up of drylands. The increasing frequency of dust and sand storms within and across the dryland region is a major concern in China as creeping desertification is swallowing thousands of square kilometres of productive soil every year. It's a challenge of gigantic and unprecedented proportions. The Gobi desert, which spans China and Mongolia, is the world's second largest dust source, after the Sahara. Although the desert itself is some distance from Beijing, reports from field studies suggest that large sand dunes are forming not far from the city.

The Chinese government have implemented a series of large-scale mitigation programs focusing on increasing vegetation cover by prohibiting grazing, planting trees and grasses, and constructing shelter forests to protect farmland against blowing sand. This has helped in some areas but not in others where desertification has continued to expand. Some scientists question the effectiveness of planting trees in drylands and especially in arid areas that lack sufficient precipitation to sustain trees in the long term (Feng *et al.*, 2015).

The UN estimates that at present 70% of drylands and about 25% of the total land area of the world is undergoing desertification (UN DESA, 2004).

In semi-arid areas like Africa, land is increasingly used for extensive farming of crops which are not used to feed the local human population but are exported to developed countries as cattle feed or used for cattle grazing. This use of land is an important factor responsible for much desertification (Baroni *et al.*, 2007).

The impacts of desertification can be seen in the Sahel, a region spanning North Africa below the Sahara Desert. It includes parts of Burkina Faso, Chad, Djibouti, Eritrea, Ethiopia, Mali, Mauritania, Niger, Nigeria, Senegal and Sudan. Rainfall is low (4-24 inches per year) and droughts are frequent. It is one of the world's largest water-limited environments and is particularly vulnerable to climate change and human activities (Kaptué *et al*., 2015).

Traditionally here, land had been cleared for crops, but over the years without shelter from trees, the topsoil dried up and blew away. Rainfall ran off instead of soaking into cropland and the level of desertification has been very high. However, in the last 20 years, there has been some 'regreening' of the Sahel through the planting of trees and vegetation recovery (Kaptué *et al*., 2015).

Extreme drought contributes to desertification too as seen in California. Forests of California are of particular interest because they include the tallest, biggest and oldest trees on Earth. They provide habitat for numerous plant and animal species, carbon storage for climate change mitigation, water provisioning for a myriad of industries and communities, timber for wood products and ecotourism (Asner *et al.*, 2016).
NASA's senior water scientist, Dr James Famiglietti, told The Huffington Post that the 2015 action film Mad Max: Fury Road is pretty extreme but that elements of it could be possible:

"Of course, there are desert regions on Earth that already look like that – like those in the film – so the question is, will more of Earth's wet regions be converted into dry ones? Our climate models certainly predict increasing 'desertification,' which will be particularly difficult for those regions, like the Sahel, that are on the boundary between wet and dry. There are metaphorical elements of 'Mad Max' that are already happening, and that will only worsen with time" (Howard, 2016).

Land degradation

Each year about 90% of US cropland loses soil at a rate 13 times above the sustainable rate of one ton per hectare per year, and pastures and rangelands are losing soil at an average of six times that. About 60% of pastureland in the US is being overgrazed and is subject to accelerated erosion (Pimentel and Pimentel, 2003).

In the UK, agricultural soils are being degraded by intensive farming practices in some areas, with deep ploughing, short rotation periods and exposed ground leading to soil erosion from wind and heavy rain. The situation is likely to worsen with water shortages and drier soil conditions resulting from climate change (Committee on Climate Change, 2015).

Maize is considered a high-risk erosion crop as the plants leave soil exposed during much of the growing season. Where maize is replacing grassland, the risks of erosion are even higher, especially if it is planted on slopes. From 1998 to 2014, there has been a seven-fold increase in the area of land in the UK planted with maize (from 27,000 to 196,000 hectares). Of this, much is grown in the Southwest. Most of the maize grown in the UK is used – you've guessed it – to feed livestock. Around 15% (29,000 hectares in 2014) used

to produce bio-energy (Committee on Climate Change, 2015).

Soils are essentially a non-renewable natural asset, critical for agricultural production. They also provide a range of wider benefits, including carbon storage and slowing the water cycle (Committee on Climate Change, 2015). 'Soil organic carbon' is the carbon stored in soil in organic plant and animal materials at various stages of decay. **An estimated 10 billion tonnes of carbon are stored in UK soils, 50 times the carbon stored in UK vegetation (Defra, 2009).** Due to losses of soil organic carbon, around 12 million tonnes of CO_2 is emitted to the atmosphere each year from UK soils (Committee on Climate Change, 2015).

Human activity is responsible for the continuing desertification we are witnessing around the globe. Drastic action is required immediately if we are to attempt to halt and reverse what is sometimes called desert creep.

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Air pollution

Agriculture is the biggest single cause of the worst air pollution in Europe, the eastern US and regions west of Beijing as nitrogen compounds from fertilisers and animal waste drift over industrial regions (Bauer *et al.*, 2016). While emissions from local transport and industrial activities are important contributors to urban pollution, it has been shown that agricultural ammonia emissions are a major driver (Vieno *et al*., 2016).

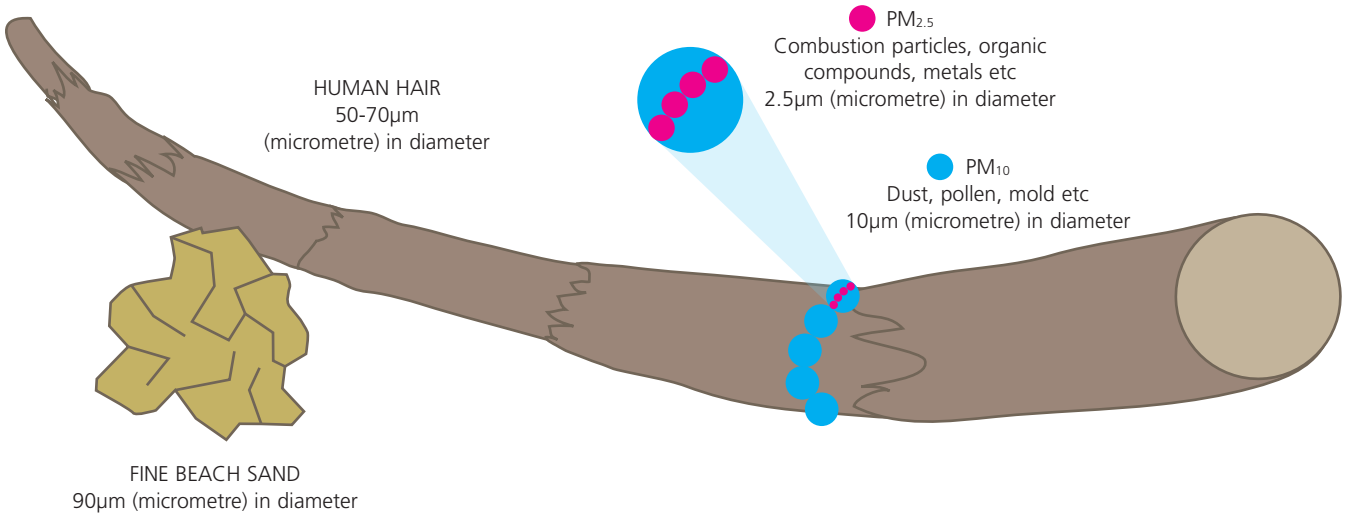
Agricultural air pollution comes mainly in the form of nitrogen-containing ammonia (NH3), which enters the air as a gas from heavily fertilised fields and livestock waste. Research from the Earth Institute at Columbia University in the US, published in the journal *Geophysical Research Letters*, found that when such nitrogen compounds are mixed with pollutants from industry, they combine to form tiny, solid particles (about one thirtieth the width of a human hair) small enough to invade even the smallest airways. These 'particulate pollutants' can stick in the fine lung tissue of children and adults, causing breathing difficulties, damaging heart and lung function and may cause premature death. An increasing body of evidence suggests that this is now a leading source of air pollution in Europe, much of the US, Russia and China (Bauer *et al.*, 2016).

Particulate matter (PM) is the term used to describe solid particles in the atmosphere. Their potential for causing health problems is directly linked to their size. $PM_{2.5}$ are fine inhalable particles with a diameter of 2.5 micrometres or smaller. The average human hair is about 70 micrometres in diameter – making it 30 times larger.

A report published by the Royal College of Physicians and the Royal College of Paediatrics and Child Health, estimates that more than **40,000 people a year die prematurely in the UK because of air pollution**. They suggest that the adverse impact on public health caused by pollution costs the UK economy more than £20 billion per year, almost 16% of the current annual NHS budget (Royal College of Physicians, 2016).

The situation is expected to worsen due to the large anticipated increase in ammonia emissions from agriculture as the demand for meat increases (Bauer *et al.*, 2016). **This problem should be declared a public health emergency but while politicians focus on replacing diesel cars with ones that run on petrol, the problem of how to control pollution from agriculture remains largely ignored.**

While cutting down on industrial pollution from coal-fired power stations and using more efficient vehicles (electric cars) would help, other particulates can also combine with nitrogen compounds including dust such as the Saharan desert sands that contributed to a major pollution event in the UK in 2014. This episode was widely perceived as being a 'natural' phenomenon caused by dust blowing over from the Sahara. However, we now know that it was only partly caused by dust and most of the problem came from agricultural ammonia emissions from Europe mixing with local pollution from industry and traffic. Scientists writing in the journal *Environmental Research Letters* said that reducing emissions in Europe would have marked benefits in reducing air pollution in the UK (Vieno *et al.*, 2016).



Source: US EPA, 2017.

A reduction in either nitrogen oxides produced during combustion or agricultural ammonia would lead to reduced air pollution (Bauer *et al*., 2016).

Similar, but more severe pollution episodes have been seen in China and other fast-growing economies (Oh *et al*., 2015; Yan *et al*., 2015, Zhang *et al*., 2015, Zhou *et al.,* 2015, Tan *et al*., 2017). These are worse than episodes seen in the UK, Paris and other parts of Europe (Gualtieri *et al*., 2015), but if nothing changes, it doesn't bode well for Europe.

A 2015 study in the journal *Nature* estimates that **fine particulate pollutants cause at least 3.3 million premature deaths each year globally** and suggests if nothing changes, this could double by 2050. According to this study, China suffers the worst, followed by India.

Air pollution is caused by a range of factors. Residential energy use is the biggest contributor in many parts of Asia, natural sources of air pollution are dominant in much of northern Africa and the Middle East. Power generation is the biggest source in much of the US, **but agriculture is the biggest factor in Europe** (Lelieveld *et al.*, 2015).

The number of deaths caused by outdoor air pollution could double by 2050 (Lelieveld *et al.*, 2015). Most people assume that industry and traffic are the main causes of air pollution. The much-overlooked and substantial role played by agriculture suggests that policymakers should pay more attention to reducing this source.

Reducing CO_2 emissions generally requires a switch to solar- or wind-generated energy, which also cuts down on sources of particulate air pollution. Introducing cleaner technologies has the bonus effect of reducing greenhouse gas emissions. It's a win-win situation. Reducing air pollution could save the world in more than one way. It's an important consideration and one that could mean the difference between life and death for millions of people every year.

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World hunger

Growing crops to feed to animals is a highly inefficient way of producing food that simply can't meet demand. Dr Jonathan Foley, Director of the Institute on the Environment at the University of Minnesota says: ***"Using highly productive croplands to produce animal feed, no matter how efficiently, represents a net drain on the world's potential food supply"*** (Foley, 2011).

Around one-third of global cropland is used to grow animal feed (FAO, 2006).

An increasing number of government guidelines now recommend that people eat less meat (FAO, 2006; Foley, 2011). For example, the UK government recommends eating no more than 70g of red or processed meat (two slices of bacon a day) but does not specify a limit on white meat. In 2013, the average intake of red and white meat combined in the UK was 223g per day (FAOSTAT, 2017).

Over the last 50 years, the global population has doubled (from around three to more than six billion people) but global food demand has tripled. This is because as living standards have risen, the demand for animal foods has increased (Bodirsky *et al.*, 2015).

The United Nations' Food and Agriculture Organisation (FAO) says that one in nine (795 million of the 7.3 billion people in the world), are currently suffering from chronic undernourishment (FAO, 2015). Being undernourished is defined as being underweight for one's age, too short for one's age (stunted), dangerously thin for one's height (wasted), and/or deficient in vitamins and minerals (micronutrient malnutrition).

- **One in nine people in the world today (815 million) are undernourished**
- **Most live in developing countries, where 12.9% are undernourished**
- **Two thirds of the people in Asia are undernourished**
- **Poor nutrition causes nearly half (45%) of deaths in children under five – 3.1 million children each year**
- **One in four of the world's children suffer stunted growth**
- **66 million primary school-age children go to school hungry – 23 million in Africa**

Source: FAO, 2017.

The pressure on the world's food supply in the coming years will continue to rise as the population and the demand for meat grows. Add to that the rise in demand for biofuels as we switch to cleaner energy

and it is clear there will be a tremendous burden on the world's croplands (Cassidy *et al.*, 2013). **Agriculture is at the heart of this challenge – it is the world's single largest driver of global environmental change** (Rockström *et al.*, 2017).

Improving crop yields might help a bit but simply won't be enough to prevent an increase in world hunger. Whereas it is possible to dramatically increase the availability of food in the world by shifting the allocation of crops from animal feed and biofuels towards more direct means of feeding people (Cassidy *et al.*, 2013).

The United Nations' Sustainable Development Goals (SDGs) set a number of goals, one of which is to end world hunger by 2030: **"*End hunger, achieve food security and improved nutrition and promote sustainable agriculture*"** (FAO, 2017a).

Agriculture is the key to attaining the UN's goal of eradicating hunger and securing food for a global population of nine billion by 2050 – which may require an increase in global food production of between 60-110% (Rockström *et al.*, 2017).

As global incomes increase, diets shift from those containing plant-based foods to ones rich in meat, dairy and eggs. The shift to more intensive demand for animal products is called the 'Livestock Revolution' and it is estimated approximately 40% of the world's population will undergo this revolution towards more animal consumption by 2050 (Cassidy *et al.*, 2013).

Feeding food that humans could eat to animals, so that humans can eat them, is clearly a waste of precious resources: 36% of the calories from crops are currently used for animal feed but only 12% of those feed calories find their way into the human diet as meat and other animal foods (Cassidy *et al*., 2013).

If animals were considered as 'food production machines', they would turn out to be extremely polluting, to have a very high consumption and to be very inefficient. When vegetables are transformed into animal protein, most of the protein and energy contained in the vegetables are lost; used by the animals for their metabolic processes, as well as to build non-edible tissue like bones, cartilage, offal and faeces (Moriconi, 2001).

We all know how wasteful old gas-guzzling cars are – how long before livestock farming is viewed the same way?

Growing food solely for human consumption, without feeding it through farmed animals, could increase available calories by as much as 70%, which could feed an additional four billion people – more than the projected two or three billion predicted in population growth by 2050 (Cassidy *et al.*, 2013). There really is no excuse for wasteful Western diets.

In addition to growing meat and dairy demands, affluent nations are also channeling a growing proportion of high-value crops into biofuel production. Much of this could be eaten by people, especially maize in the US and sugarcane in Brazil. In 2010, global biofuel production represented 2.7% of global fuel for road transportation, which is more than a 450% increase from the year 2000 (Cassidy *et al.*, 2013).

We may have a global economy, but the huge disparities between rich and poor, and the persistent depletion of environmental resources used in food production on land and at sea, prevent us from reducing the very basic public-health problem of world hunger.

So if you choose to cut out the middleman (the cow, sheep, pig, chicken and fish) and get your calories directly from plant-based foods, world hunger really could become a thing of the past.

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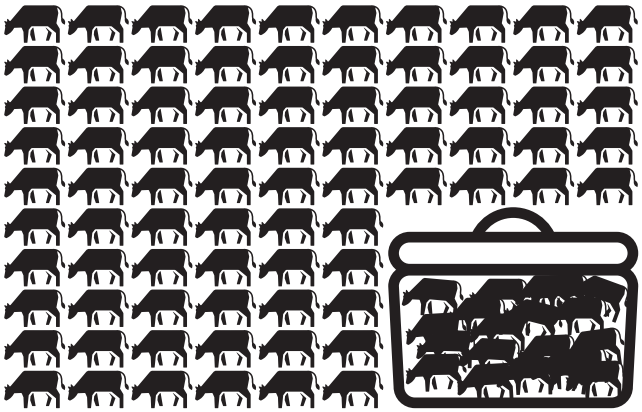
Food waste

If food wastage were a country, it would be the third largest emitting country in the world
(FAO, 2013)

Each year 1.3 billion tonnes of food – **a third of all food produced** – is wasted, including 45% of all fruit and vegetables, 35% of fish and seafood, 30% of cereals, 20% of dairy products and 20% of meat (FAO, 2017). So a third of all food produced in the world for human consumption never even reaches our plates.



Of the 263 million tonnes of meat produced globally, over 20% is wasted. That's equivalent to 75 million cows (FAO, 2017).

In Europe, 29 million tonnes of dairy foods and eggs are wasted every year – that's equivalent to 574 billion eggs (FAO, 2017).

This amounts to an extraordinary amount of living creatures born to be wasted. The UN FAO say this not only means a missed opportunity for the economy and food security, but also is a waste of all the natural resources used for growing, processing, packaging, transporting and marketing the wasted food (FAO, 2013).

Reducing food loss and waste is one of the most promising ways to improve food security and combat climate change in the coming years (Kummu *et al.*, 2012).

The average family in the UK throws away £700 worth of perfectly good food a year, that's almost £60 worth of food a month (House of Commons Environment, Food and Rural Affairs Committee, 2017).

In the UK, avoidable waste (food that could have been eaten) increased by 5.1% (from 4.2 to 4.4 million tonnes) between 2012 and 2015. Food with a retail value of around £13 billion was thrown away rather than being eaten in 2015. This avoidable household food waste was associated with 19 million tonnes of CO_2e, which is equivalent to the emissions generated by one in every four cars on UK roads (WRAP, 2015). Imagine the effect of taking one in every four cars off the road each and every day.

Food waste represents a major squandering of resources, including land, water and energy as well as needlessly producing greenhouse gas emissions, contributing to global warming and climate change:

- **Food waste uses up nearly 1.4 billion hectares of land – that's nearly 30% of the world's agricultural land area (FAO, 2013).**
- **Globally, the freshwater footprint (the consumption of surface and groundwater resources) of food waste is about 250 km3, equivalent to three times the volume of Lake Geneva or the annual water discharge of the Volga river – the largest river in Europe (FAO 2013).**
- **Global food waste generates annually 4.4 $GtCO_2e$ – about 8% of total greenhouse gas emissions (EC JRC/PBL, 2012).**

So, we are wasting precious resources producing food that will never be eaten and will use up even more resources being disposed of. Additionally as it rots in landfill it produces methane further contributing to global warming.

If food waste was a country, it would be the third top emitter, after the US and China, producing more than twice the total emissions of all US road transportation in 2010 (FAO, 2013).

All food waste is not equally wasteful. Wastage of meat has a much higher impact on the environment in terms of land use and carbon footprint, especially in high income regions (that waste about 67% of meat) and Latin America (FAO, 2013). So, although less meat, dairy and eggs are wasted (on average) compared to fruit and vegetables, **animal food waste is the biggest contributor to greenhouse gas emissions from all food waste**, despite ranking fourth in food waste by weight (Costello *et al*., 2016).

Food loss is widely recognised as undermining food security and environmental sustainability. However, choosing resource-intensive meat and dairy foods, instead of more efficient, equally or more nutritious alternatives can also be considered as an effective food loss (Shepon *et al.*, 2018).

If everyone in the US went vegan, an additional 350 million people could be fed (Shepon *et al.*, 2018).

With a third of all food production lost, through inefficient supply chains or spoilage, food loss is a key contributor to global food insecurity. Demand for resource-intensive animal foods (meat and dairy) further limits food availability. Plant-based alternatives to beef, pork, dairy, poultry and eggs can produce between two and 20 times as much food using the same amount of land. Going 100% vegan in the US alone could add enough food to feed 350 million additional people, more than the expected benefits of eliminating all supply chain food loss (Shepon *et al.*, 2018).

Ronald G. McGarvey, assistant professor at the Harry S Truman School of Public Affairs, says: *"…we recommend consumers pay special attention to avoiding waste when purchasing and preparing meat; if consumers choose to prepare extra food 'just in case,' they should use plant-based foods"* (Narverud, 2015).

Your food isn't rubbish – keep it out of landfill. Saving food means contributing to a better legacy for generations to come.

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Palm oil

Did you know that household items containing palm oil, such as shampoo and shaving gel, are contributing to climate change, biodiversity loss and social deprivation?

Palm oil is a $62 billion industry and an ingredient found in roughly half of all items on supermarket shelves (UNEP, 2016).

Palm oil is extracted from the pulp of the fruit of oil palms. It is the world's highest yielding and least expensive vegetable oil, making it a popular choice for millions of people globally and a source of biofuel. **Around 74% of global palm oil is used in food products and 24% is used for industrial purposes – mostly biodiesel** (Lees *et al.,* 2016).

Palm oil is the most widely consumed vegetable oil worldwide and half of all packaged products contain it (WWF, 2019). From ice cream and instant noodles, to shampoo and lipstick, the demand for cheap palm oil is steadily rising. **Between 2003 and 2014 palm oil production doubled** (FAOSTAT, 2017).

Most oil palms grow in areas that were once tropical forests. **Oil palm plantations now dominate tropical land-use, occupying over 16 million hectares** (Lees *et al.,* 2016). Expansion threatens biodiversity and increases greenhouse gas emissions (Vijay *et al.*, 2016).

Because the oil palm's range is limited to the humid tropics, expansion has come at the expense of species-rich and carbon-rich tropical forests (Vijay *et al.*, 2016). **Oil palm plantation monocultures are an emerging threat to Amazonian biodiversity; whilst expansion of plantations across the tropics elsewhere has caused massive loss of tropical forest habitats and biodiversity** (USDA, 2010). Resident species like elephants, orangutans, rhinos and tigers have lost their homes and some indigenous peoples have been forced off their land, losing their livelihoods.

The island Borneo is divided among three countries: Malaysia and Brunei in the north, and Indonesia to the south. Plantation industries have been the principle driver of deforestation in Malaysian Borneo over the last four decades. Their role in deforestation in Indonesian Borneo was less marked, but has been growing recently (Gaveau *et al.*, 2016).

Deforestation to make way for the plantations has also exacerbated climate change (WWF, 2016). Around 90% of the world's oil palm trees are grown on a few islands in Malaysia and Indonesia – islands containing some of the greatest biodiversity on Earth. Here, there is a direct relationship between plantations and deforestation (WWF, 2016).

The Southeast Asian Haze

Fires set in forests and on carbon-rich peatland to quickly clear land for palm oil plantations can lead to significant emissions with impacts seen at a regional and even global scale (Hayasaka *et al.*, 2014). The 2015 **Southeast Asian haze** was an air pollution crisis caused by fires that affected several countries including Brunei, Indonesia (especially Sumatra and Borneo), Malaysia, Singapore, southern Thailand, Vietnam, Cambodia and the Philippines.

The fires were blamed for up to half a million cases of respiratory infections and endangered animals were forced to flee the forests. Six Indonesian provinces declared a state of emergency, schools in neighbouring Singapore and Malaysia were closed and flights grounded. One study estimates that it caused 100,300 deaths across Indonesia, Malaysia and Singapore (Koplitz *et al.*, 2016).

The negative impacts of oil palm development on biodiversity, and on orangutans in particular, have been well documented (Wich *et al.*, 2014). **Orangutans** are great apes native to Indonesia and Malaysia, currently found only in the rainforests of Borneo and Sumatra. They used to be considered as one species but since 1996 they have been divided into two species: Bornean orangutans and Sumatran orangutans. The expansion of plantations has caused substantial losses of their natural habitat and now both species are endangered, particularly the Sumatran orangutan which is critically endangered (IUCN, 2017). **We should be able to brush our teeth or eat a snack without pushing orangutans into extinction.**

The main organisation responsible for the certification of sustainable palm oil is the **Roundtable on Sustainable Palm Oil** (RSPO). Set up in 2004, the RSPO is composed of palm oil producers, processors and traders, manufacturers, retailers, investors and NGOs. Companies must comply with the RSPO's environmental criteria if they are to produce 'Certified Sustainable Palm Oil' (RSPO, 2017). The system relies on the ability of auditors to monitor the operations of palm oil growers. Around a fifth of the world's palm oil is certified by the RSPO.

However, the RSPO standard does not prohibit deforestation or clearance of peatlands, nor does it require protection of landscapes with high carbon stocks. This places the RSPO out of step with major companies and traders who are committing to 'zero' deforestation, peatland or high carbon stock developments (EIA, 2015).

Furthermore, NGOs have raised concerns about the monitoring and enforcement of standards for RSPO certification (Vijay *et al.*, 2016). In 2015, the Environmental Investigation Agency (EIA), a not-for-profit UK organisation, claimed that companies auditing RSPO certified plantations were failing to identify violations and in some cases colluding to deliberately disguise them, leading to deforestation, human trafficking and intimidation of environmentalists (EIA, 2015). EIA said: ***"Until credible reform is in place, buyers must exercise due diligence to determine the source of their palm oil – or risk the many products on supermarket shelves being tainted with human trafficking, human rights abuses and species extinction"*** (EIA, 2015).

The RSPO have expelled two of the companies accused of malpractice in the EIA report and say they believe that the nine case studies presented by EIA, however serious, cannot lead to a general dismissal of the RSPO certification system (RSPO, 2015). In 2016 they introduced an auditor registry in partnership with a third-party oversight body, Accreditation Service International, to ensure better oversight of RSPO auditors.

Some companies promise their customers that they will ensure the palm oil they buy is not linked to deforestation. However, many remain unable to say with confidence that the palm oil they use is not driving the destruction of rainforests, threatening endangered species or contributing to social conflicts.

In 2015, Greenpeace produced a 'Company Scorecard' of 14 major brands (Colgate-Palmolive, Danone,

Ferrero, General Mills, Ikea, Johnson & Johnson, Kellogg's, Mars, Mondelez, Nestle, Orkla, PepsiCo, P&G and Unilever), on how they are fulfilling 'zero-deforestation' commitments (Greenpeace, 2015). It showed that **none of the companies could guarantee their supply of palm oil is not linked to deforestation**.

Because Indonesia and Malaysia together account for approximately 80% of global palm oil production, most of the focus falls on these countries. However, oil palm is currently grown in 43 countries so future expansion is likely to occur in other areas too. The largest forested areas that future oil palm development threatens are in South America and Africa (Vijay *et al.*, 2016). There is concern that this will lead to biodiversity losses similar to those already seen in Southeast Asia (Wich *et al.*, 2014).

The United Nations Environment Programme (UNEP) supports collaboration between the international conservation community and palm oil developers in order to create sustainable strategies that will save fragile ecosystems and the species that inhabit them, particularly apes (UNEP, 2016). Their 2016 report, *Palm Oil Paradox: Sustainable Solutions to Save the Great Apes*, includes steps required to ensure that the loss of biodiversity that occurred in Southeast Asia are not repeated as the oil palm plantations expand into Africa.

Great Apes Survival Partnership coordinator Doug Cress said: "*This report recognizes that palm oil is here to stay and the hard line boycotts are unlikely to achieve success*."

Report editor Dr Erik Meijaard said: **"*It's time we recognised that the land-use choices we make as human beings can have devastating results not just for ourselves, but for biodiversity. The climatic conditions that now occur regularly in Southeast Asia – floods, the fires, the temperature rises – are no accident. Africa may seem vast and limitless as a future site for palm oil, but Borneo and Sumatra once did, too.*"**

Sustainable production of palm oil must include solid promises that any expansion growth does not come at the expense of existing forest habitats through direct or indirect deforestation (Strassburg *et al.*, 2014).

Government regulation and public pressure is required to ensure that the expansion of oil palm plantations occurs in ways that protect biodiversity-rich ecosystems and prevents further deforestation (Vijay *et al.*, 2016).

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Soya

Do you think soya is something only vegans eat? Think again. Due to the increasing global demand for meat and dairy, soya has become one of the world's biggest crops – because most of it is used to feed animals (WWF, 2014). Increasing meat consumption is driving soya's relentless expansion.

Pulses (legumes) include peas, beans, lentils, soya and other podded food plants. Pulses have been cultivated for thousands of years and play an important role in the diets of many people around the world. It's impossible to imagine the traditional foods of India, South America, Mexico, the Middle East and Asia without lentils, black beans, pinto beans, chickpeas and soya beans (Messina, 1999).

Soya beans contain around 40% protein and 20% fat (Reinwald *et al.*, 2010). The fat content is so high in fact that the UN FAO class soya as an oilseed rather than a pulse, whereas in the US it is classed as a grain.

"…soybeans can produce at least twice as much protein per acre than any other major vegetable or grain crop besides hemp, five to 10 times more protein per acre than land set aside for grazing animals to make milk, and up to 15 times more protein per acre than land set aside for meat production" (Head, 2016).

Soya produces more protein per hectare than any other major crop and has a higher percentage of protein than many animal foods (WWF, 2014). Soya can feed more people per acre than almost any other plant which makes it a highly desirable crop – but not just for people.

Around three-quarters of the world's soya is used for animal feed (WWF, 2014). The vast majority is milled into high-protein soya meal, which has become the world's number-one animal feed.

Soya oil is used for cooking, in margarines and in other consumer goods, such as cosmetics and soaps. Soya oil is also increasingly used as a biofuel. Soya derivatives, like the emulsifier lecithin, are used in a wide range of processed foods, including chocolate, ice cream and baked goods (WWF, 2014).

In the US, more than nine billion livestock are farmed to meet the demand for meat and dairy, outweighing the US human population by about five times and consuming more than seven times as much grain as the entire American population (Pimentel and Pimentel, 2003). The amount of grain fed to US livestock would feed about 840 million people following a plant-based diet (Pimentel and Pimentel, 2003).

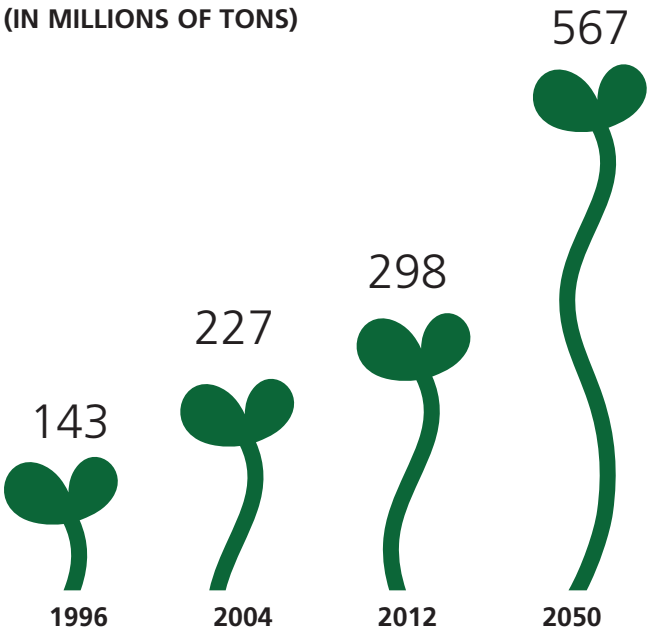
In the UK, around 20% of animal feed is imported from outside the EU, as the amount of home-produced feed is insufficient to meet demand. Soya beans and soya bean meal from North and South America and maize

gluten feed from the US are the main imported feed materials (FSA, 2017).

Soya has come a long way since it originated in China around three thousand years BC. It was introduced to Europe and North America in the 18th century, but wasn't grown on a significant scale outside Asia until relatively recently. Large-scale production took off in the US after World War II and by 1970 it was producing three-quarters of the global crop. When the US began running out of suitable land for expansion, soya began its long march into South America (WWF, 2014).

In the last 50 years, global soya production has grown tenfold, from 27 to 269 million tons in 2014 (WWF, 2014). In 2017, the United States Department of Agriculture (USDA), estimated its production at 348 million tons, an increase of 35 million (11%) in just one year (Global Soybean Production, 2017). By 2050, soya production could be as high as 567 million tons (Bruinsma, 2009).

GLOBAL SOYA PRODUCTION (IN MILLIONS OF TONS)



Source: Bruinsma, 2009; USDA-FAS, 2013; FAO, 2007.

Soya now covers over one million square kilometres (386,100 square miles) equivalent to the total combined area of France, Germany, Belgium and the Netherlands (WWF, 2014).

Growing demand from the EU and more recently from China, is the main driver behind the expansion of soya. Sadly, the popularity of this humble bean has nothing to do with its original use in tofu, miso, soya milk and soya sauce. The desire, from both industrialised and industrialising countries, is driven by its suitability for animal feed.

We are taking a highly nutritious plant food and feeding it to animals to produce meat and dairy foods for people – this is inefficient and wasteful. **Compared to soya protein, meat requires 6-17 times more land, 4-26 times more water and 6-20 times more fossil fuels (Reijnders and Soret, 2003).**

A third of the world's soya (33%) is grown in the US, 31% in Brazil and 16% in Argentina (Global Soybean Production, 2017).

Over 90% of the world's soya comes from just six countries: the US, Brazil, Argentina, China, India and Paraguay (Global Soybean Production, 2017).

In 1995, China was self-sufficient in soya beans, producing five million tons a year. However, rising living standards have led to many people adopting a more Western-style diet, consuming more meat and dairy. By 2017 China was producing 13.8 million tons a year and importing even more. The USDA expected that China would import over 90 million tons in the 2016-2017 marketing year accounting for nearly two-thirds of the world's imports (Braun, 2016).

The situation is getting worse as the number of farmed animals rises to meet the insatiable demand for meat. There simply is not enough agricultural land available to meet demand and forests are being torn down to accommodate huge expanding monocultures of soya beans. **Around 70% of previously forested land in the Amazon is used for grazing with animal feed crops covering a large part of the remainder** (UN/FAO, 2006).

The inefficiency of feeding plant foods to animals for meat has resulted in livestock dominating 75% of the world's agricultural land for either grazing or growing animal feed (Foley *et al.*, 2011). There simply is not any room left so the focus has shifted to the destruction of

forested land to make more room for grazing and growing soya beans (UN/FAO, 2006). This destruction is an environmental disaster and loss of forests is a major contributor to greenhouse gas emissions and global warming.

Soya beans are no more environmentally damaging than any other bean, in fact they are less so because of their superior nutritional composition. The fact that soya bean cultivation is causing environmental havoc across the globe is often used as a criticism of veganism, but it is meat-eating that is driving soya expansion. Only around 6% of soya beans are used directly as food, mainly in Asian countries such as China, Japan and Indonesia (WWF, 2014).

Much of the soya foods consumed in the UK are made with organic beans sourced from Europe and the US (unlike the genetically-modified soya grown for animal feed). Plant-based milk manufacturers Alpro do not source soya from the Amazon, they buy from farmers that they have direct contact with (mainly in France) and never buy soya on the open market to ensure full traceability (Alpro, 2018).

For over 3,000 years soya products formed an essential part of Chinese people's diet and even when its population reached more than a billion it was still self-sufficient in soya. It was only when they turned to the mass consumption of meat and dairy that their demand for soya exceeded their ability to grow it.

The decision to change to a vegan diet is better, not just for the animals themselves and the rainforest, but also for all the other environmental catastrophes that are linked to livestock production – expanding deserts, soil degradation, global warming, nitrogen pollution, antibiotic resistance and superbugs. The widescale adoption of a vegan diet would stop soya expansion in its tracks.

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Conclusion

Livestock farming is at the heart of all the climate change problems we are facing from the destruction of rainforests and oceans to the polluting of the air we breathe. We are currently undergoing a sixth mass extinction with no idea what the consequences of the huge loss of biodiversity will be. It's like driving a car along a cliff edge while wearing a blindfold.

The government's refusal to name and shame animal farming as a major driver of climate change, and many of the other environmental catastrophes that afflict our globe, makes it necessary for groups like Viva! to draw attention to the devastating effects eating meat and dairy foods is having on our planet. If we don't talk about it, who will?

This timely report reveals the devastating impact livestock farming is having on our planet, investigating all aspects including global warming, land use, overfishing, water use, biodiversity, deforestation, antibiotic resistance, desertification, air pollution, world hunger and food waste. Chapters on palm oil and soya production explain the problems and myths associated with these crops. The message coming from climate scientists from all corners of the globe is clear; there is still time to turn things around – but only just. Urgent and drastic action is required now if we are to avert disaster.

NASA scientist James Hansen warned the US congress about the 'greenhouse effect' in the 1980's. His warnings went unheeded as governments chose to

invest in expanding fossil fuel industries with no consideration for the long-term consequences. They are still largely ignoring the warnings, which are now coming thick and fast from hundreds, indeed thousands of concerned scientists.

Changing the way we eat would be the single most effective change we could make to lower our impact on the environment. More effective than buying an electric car or using energy efficient light bulbs, the widespread adoption of a vegan diet could reduce food emissions from 50-80%. If we stand any chance of achieving zero emissions, changing our diet has to be pushed up the agenda.

You can reduce your personal emissions and land use footprint by 70-80% and water consumption by 50% just by adopting sustainable dietary patterns. If we stopped feeding a third of all crops to animals, much less land would be required but there would be much more food for all. This one action could provide enough food for an additional four billion people – more than the projected two or three billion increase in population by 2050. There really is no excuse for wasteful Western diets, loaded with meat, fish, eggs and dairy foods.

Another huge bonus is that grazing land could revert to forest which would remove CO_2 from the atmosphere. This simple change could have an enormous impact in helping us achieve net-zero emissions.

The Intergovernmental Panel on Climate Change (IPCC) have issued repeated stark warnings about the impending, devastating consequences of unmitigated climate change. It is not just extreme weather events, rising sea levels, floods and storm surges we need to be concerned about but political unrest, mass migrations and conflict. Future wars being fought over water are becoming a real possibility. The future of our planet is at stake and we appear to be fiddling while Rome burns!

Governments simply cannot ignore scientists any longer as doing nothing will cost much more than taking action and the world could become a very different and hostile place to live.

Swedish schoolgirl, Greta Thunberg, has inspired children across the globe to walk out of their schools to protest about the potential loss of their future. They feel it has been stolen from them, sold off to the highest bidder. Extinction Rebellion, the new protest group gathering support at an unprecedented rate, are demanding that we set legally binding targets to reduce carbon emissions to net-zero by 2025, considerably more ambitious than the current UK goal of reducing emissions by 80% by 2050. This is in line with recent IPCC warnings that limiting temperature rises to the safer 1.5°C requires the world achieving zero emissions by 2050.

People are recognising the severity of the problem but there is no clear guidance from government and diet continues to be a universal blind spot, even amongst some protest groups. It is entirely possible for the UK to achieve net-zero emissions but it will require a concerted effort and that must include a widespread change in the way we eat.

Action is long overdue and those who feel powerless and think it's up to politicians to act need to think again. The food choices we make can be part of a solution in addressing the biggest threat to the planet we have ever faced. We need politicians to listen to the science and do their job by legislating for targets rather than making hollow political declarations.

At an individual level, you can make a difference by going vegan for the future of all life on Earth!

Viva!'s ground-breaking report reveals the devastating impact livestock farming is having on our planet. It investigates all aspects of climate change from global warming, loss of biodiversity, land and water use, to soya and palm oil production. Want to know what you can do to help avert disaster? This essential report reveals all.

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Viva!