LESS IS MORE

REDUCING MEAT AND DAIRY FOR A HEALTHIER LIFE AND PLANET

The Greenpeace vision of the meat and dairy system towards 2050

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Contents

This report is based upon a more detailed technical review of the scientific evidence relating to the environmental and health implications of the production and consumption of meat and dairy products: **Tirado, R., Thompson, K.F., Miller, K.A. & Johnston, P. (2018)** ***Less is more: Reducing meat and dairy for a healthier life and planet – Scientific background on the Greenpeace vision of the meat and dairy system towards 2050.*** **Greenpeace Research Laboratories Technical Report (Review) 03-2018**

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Foreword

Professor Pete Smith

I have been working on the sustainability of agriculture and food systems for over 20 years, and over this time have been involved in hundreds of studies examining how to reduce the climate impact of agriculture, and how to make the global food system more sustainable. What I have come to realise over this period is that our current food system, and its future trajectory, is simply not sustainable, and we need to fundamentally change the way we produce food if we are to feed 9-10 billion people in 2050 without wrecking the planet irreversibly.

The component of the food system that has the largest single impact, is the production of livestock to provide products for human consumption. In addition to the large areas of land that livestock use directly, over 30% of all of the crops we produce globally go into livestock feed. Given that livestock are about 10-15% efficient (at best) in converting their feed into biomass that we can consume, livestock represent a huge efficiency bottle-neck in the food system. No wonder then, that livestock products have a water footprint many times greater than crop products, and that ruminant meat has a greenhouse gas footprint 100 times that of plant-based foods. We are not talking about percentages here – we are talking about a factor of 100!

Having looked at a range of potential options for moving toward a sustainable food system, including the full range of production-side measures available, it has become clear to me that we must significantly reduce consumption of livestock products now and into the future. Producing the same mix of foods as we consume now, even if we were to do so more sustainably, cannot deliver the reduction in environmental impacts we need to protect the planet for our children and their children.

With an increase in human population and with the gap between richer and poorer countries projected to get smaller, a rising middle class is projected to increase demand for meat, milk and other livestock products considerably. People in richer countries are already over-consuming meat and milk, to the detriment of global human health. These levels of consumption are not sustainable.

"The need to reduce demand for livestock products is now a scientifically mainstream view"

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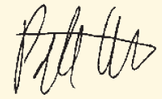
We could significantly reduce meat and milk consumption globally, which would improve human health, decrease environmental impact, help to tackle climate change, and feed more people from much less land – perhaps freeing some land for biodiversity conservation. And we do not all need to make the once-and-forever decision to become vegetarian or vegan – reduced consumption of meat and milk among people who consume "less and better" meat / milk could have a very significant impact.

During the 20 or so years I have been researching these issues, I have come to the unavoidable conclusion that we must significantly reduce livestock product consumption. This is not driven by a vegetarian/vegan ideology, or a zeal to become an eco-warrior – it is driven entirely by the scientific evidence. The need to reduce demand for livestock products is now a scientifically mainstream view.

The authors of this report have assembled the best scientific evidence from published reports covering agriculture, food systems, environmental and health research in an objective and balanced fashion. They come to the same conclusion as mainstream science has come to in recent years – the current and projected food system is unsustainable, and only a significant decrease in meat and milk consumption will allow us to deliver a food system fit for the future – for the benefit of humans and the planet as a whole.

Every day, and at every meal, we choose what we eat. We need to start making different choices, and governments need to provide policies that help us to make the right choices, that are better for our health and better for the planet. The system will need to transform to meet these challenges. This report outlines a vision for how this transformation might happen.



Prof Pete Smith, FRS, FRSE, FNA, FRSB
University of Aberdeen, 1st February 2018

An Image from the Greenpeace campaign 'Too much meat in school'. Lunch menus in a typical French primary school will often include meat on a daily basis, together with milk products

Introduction

What to eat?

For millions of years on a daily basis humans have faced the same question: *What to eat?* This is a question shared both by ancestral hunter-gatherers and working parents on their way home, wondering what to feed their family. The availability of healthy food and the consequences of the choices we make today about our daily diet can be very challenging to some, and overwhelming to others. However, not only does this question have an impact on our wellbeing but also on Earth itself.

"The answer will determine what kind of future our children will have, and perhaps the destiny of our species"

Many of us in academia and civil society believe that *What to eat?* is one of the most critical questions that will help shape our future. The answer will determine what kind of future our children will have, and perhaps the destiny of our species and many of the animals, microbes and plants inhabiting planet Earth.

What we eat nourishes us and helps us to maintain a healthy life, but bad choices can also make us very sick. What food we eat, how much, and how that food is grown, is also key to the survival of our planet.

Meat and dairy: effect on the climate

Our planet is changing and food is at the core of those changes. 2017 was the hottest year ever recorded, without an El Niño, and scientists are warning that the 'climate tide is rising fast'.[1] **The food system, including changes in land-use linked to agriculture, is currently responsible for a quarter of all greenhouse gas emissions (GHGs) that cause climate change.[2] If we do nothing, by 2050 gas emissions from the food system will represent more than half of the total global emissions associated with human activities.[3] The effect of what we eat and how we grow our food will progressively become more impactful and more threatening to our survival on Earth.**

Animal products are responsible for approximately 60% of food-related climate emissions.[4] Meat and dairy products are the elements of our diet with the greatest damaging effects upon our climate, and upon the environment in general.

The food system is also responsible for 80% of the deforestation currently taking place in some of the most biodiverse forests remaining on Earth, with livestock[5] and animal feed expansion being the most prominent single driver of this destruction.[6, 7, 8] Likewise, pollution arising from animal and feed farms contributes to the massive spread of dead zones in the oceans and the degradation of many rivers, lakes, and coastal seas.

So many species are going extinct at such a high rate that some scientists are calling this moment in time the age of the 'sixth mass extinction on Earth'.[9, 10] Agriculture, and livestock in particular, can be considered as **one of the planet's biggest drivers of global biodiversity loss. In short, what we eat is making our planet sick. But it is also making humans sick.**

1. https://www.theguardian.com/environment/2018/jan/18/2017-was-the-hottest-year-on-record-without-el-nino-boost
2. IPCC 2014: Smith, P., et al. 2014. Agriculture, Forestry and Other Land-Use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
3. Bajželj, B., et al. 2014. Importance of food-demand management for climate mitigation. Nature Climate Change, 4: 924-929
4. IPCC 2014: Smith, P., et al. 2014. Agriculture, Forestry and Other Land-Use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
5. Livestock are domesticated animals raised in an agricultural setting to produce commodities such as meat, eggs, milk, fur, leather, and wool, and often to do work
6. Hosonuma, N., et al. 2012. An assessment of deforestation and forest degradation drivers in developing countries Environmental Research Letters, 7: 044009.
7. Kissinger, G., et al. 2012. Drivers of Deforestation and Forest Degradation. A synthesis report for REDD+ Policymakers:48.
8. Campbell, B. M., et al. 2017. Agriculture production as a major driver of the Earth system exceeding planetary boundaries. Ecology and Society, 22: 8.
9. Barnosky, A. D., et al. 2011. Has the Earth's sixth mass extinction already arrived? Nature, 471: 51–57.
10. Joppa, L. N. et al. 2016. Filling biodiversity threat gaps. Science, 352: 416–418

Meat and dairy: effect on our health

Our diets have changed drastically in the past few decades. Although large regional differences remain, the general increase in the consumption of animal products is a global phenomenon. For example, from 1989 to 2000, the global consumption of animal products 'more than tripled in rural areas and almost quadrupled in urban areas'.[11] At the same time the world population that is undernourished went down from 19% to 11%, however in parallel the global percentage of overweight people increased substantially from 23% to 39% (1.9 billion currently).[12]

Increases in the consumption of animal products, refined grains and sugar have all been linked to the worldwide increase in obesity.[13] The rise in the consumption of unhealthy food means that **our diets are among the top risk factors for early death and increased risk of illness globally.** A suboptimal diet (for example, low fruit, low whole grain and low vegetable consumption, and high meat intake) is a leading risk factor for global premature mortality accounting for nearly one in every five deaths.[14] Dietary risk accounted for 10 million deaths globally in 2016, while tobacco risk was responsible for 7 million deaths in the same year.[15]

"Our diets are among the top risk factors for early death and increased risk of illness globally"

The urgency for action to change our food system has never been clearer. Fortunately, experts agree we still have time to reverse these destructive trends – if we act quickly and in a systematic way to address all sectors of our economies and societies related to food consumption.

In short, current production and consumption of meat and dairy products are damaging our planet by being a substantial driver of climate change, as well as putting our health at risk.. If we reshape food systems, both in the way we produce our food and what we decide to eat, then we can still avoid catastrophic climate change and the destruction of nature, while, at the same time, improving human health.

11. Malik, V. S., Willett, W. C. & Hu, F. B. 2012. Global obesity: trends, risk factors and policy implications. Nature Reviews Endocrinology, 9: 13
12. from 1990 and 1975 to today, respectively. As in Gordon, L. J.et al. 2017. Rewiring food systems to enhance human health and biosphere stewardship. Environmental Research Letters, 12: 100201.
13. Malik, V. S., Willett, W. C. & Hu, F. B. 2012. Global obesity: trends, risk factors and policy implications. Nature Reviews Endocrinology, 9: 13.
14. Gakidou, E., et al. 2017. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990-2013; 2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet, 390: 1345-1422.
15. Ibid.

"Greenpeace is calling for a global reduction of 50% in production and consumption of animal products by 2050"

The Greenpeace vision

In this report, we try to answer the question of *What to eat?* by reviewing the scientific evidence pointing at the ways in which changes to the global food system can help to achieve a healthy population and healthy planet. In particular, we focus on how reducing meat and dairy consumption and production can contribute to preserving climate, biodiversity and water systems, while improving the wellbeing of humans, now and into the future.

The structure of this report reflects the various threats generated by our excessive production and consumption of meat and dairy. Climate change is the clearest threat to our life on the planet requiring urgent action. For this reason, this report starts by explaining the scientific rationale for improving our dietary choices in terms of greenhouse gas emissions from the meat and dairy system (Chapter 1).

In addition to acting to prevent climate change, we must also ensure the preservation of other living creatures and ecosystems that make human life on Earth possible. We dedicate Chapter 2 to reviewing the impacts of meat and dairy systems on the environment.

Planetary health must include the health of humans. Human health is affected by what we eat and by the global changes set in motion by trends towards increasingly meat-heavy diets. Chapter 3 evaluates current scientific evidence on the impacts of a meat-heavy diet on human health and how changing our diets to include more plants and less meat and dairy could make us more healthy.

We conclude with recommendations and demands to governments, corporations and individuals on how we, if we act quickly and sensibly, can still ensure a green and peaceful planet on which our children can enjoy healthy lives.

This report clearly illustrates that the current livestock system is one of the sectors that will decide our future and survival on the planet. Greenpeace believes that this strong scientific evidence must translate into urgent global action. In order to protect the health of our children and of our planet for future generations from the impacts of industrial meat production we urgently need to start eating more plant-based food and less meat. If we choose to eat meat sometimes, the best option is to buy it from local ecological farmers.

Greenpeace is calling for a global reduction of 50% in production and consumption of animal products by 2050 as compared to the current situation[16]. Achieving this goal is possible under a vision of ecological farming. In other words, we propose a level of production that ensures food security while protecting the climate and biodiversity.

16. Please note that the latest data from FAOSTAT is year 2013 (as of January 2018), so that is the reference year for the Greenpeace goal.

Our approach to Meat and Dairy

Although not all meat types are equally harmful in terms of their contribution to climate change, degradation of the wider environment and the negative effects on human health, we conclude that the best approach is to tackle the meat and dairy sector in a holistic[1] way, including all types of animal products from both a production and consumption perspective.

Many animal products have significant negative environmental and social impacts relative to plant-rich foods. The magnitude of the impact of each food can differ in terms of the specific elements associated with it, for example, climate gases related to a per kilo unit. Other impacts are indirect and transversal, such as those that involve workers rights or animal welfare.[2, 3] Hence the suggestion that the best approach is a holistic one.

Human preferences for different animal products are undergoing significant shifts. So while chicken can be seen as less impactful than beef on a kg by kg comparison of climate emissions, the global environmental footprint of chicken production and consumption is massive. This is due to the **fast rising trend in poultry consumption and the very large absolute production and consumption volumes.**

Between 1990 and 2013, while there was a 10% decrease in global beef consumption per capita, there was a 23% increase in pork and a striking 96% increase in poultry consumption (Figure 1). The production of pigs and chickens already represents 70% of the total meat production globally. China's consumption of pigs and chicken has become globally relevant, as the country imports 20% of the total soy production exported from Brazil, as non-ruminant feed.[4] As such it is important to consider the negative environmental contribution of other meat types, besides beef, to land-use changes and deforestation linked to the production of feed, of which poultry and pork are big consumers.

In addition, growth in total meat consumption is projected to be driven largely by poultry and pork, not beef or other red meats such as sheep or goat. Poultry is expected to overtake pork as the most consumed meat in the world by 2022.[5] Likewise, the consumption of milk and dairy products is expected to rise, with production increasing by more than 1.8% per year. This growth will be most intense in countries like China, India and Brazil.[6] Dairy cows are also a major consumer of feed crops.

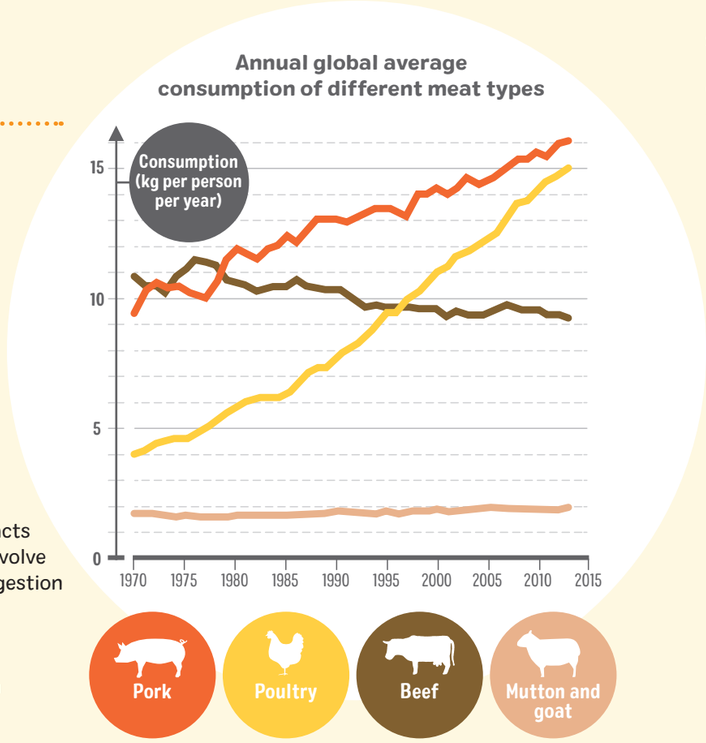


Figure 1. Consumption of beef, mutton and goat meat, pork and poultry meat, the major meat types globally, from 1970 to 2013 in kg of product per person per year (carcass weight, meaning raw unprocessed products at the point of retail sale).Data from FAOSTAT, 2018.

Feed production has significant negative impacts on forests, water resources and our climate, and contributes to food insecurity where land is used to feed animals instead of feeding people directly. Conversion of feed to animal food is largely inefficient. As little as 3% of the plant calories in feed are converted into calories in beef, for example.[7]

Different types of meat have negative impacts on various key issues. While beef production has greater impact on the climate, chicken is often at the centre of foodborne infectious disease problems because of associated bacteria and other pathogens. *Campylobacter* and *Salmonella* infections account for more than 90% of all reported cases of bacteria-

1. Holistic: systemic approach in which the parts of something are considered to be intimately interconnected and explicable only by reference to the whole. Ecological problems usually require holistic solutions.
2. Oxfam America 2015. Lives on the Line - the human cost of cheap chicken.
3. IATP et al. 2017. The rise of big meat. Brazil's extractive industry.
4. Galloway, J. N.et al. 2007. International Trade in Meat: The Tip of the Pork Chop. Ambio, 36: 622-629.
5. Henchion, M., et al. 2014. Meat consumption: Trends and quality matters. Meat Science, 98: 561-568.
6. FAO 2010: Status of and Prospects for Smallholder Milk Production – A Global Perspective, by T. Hemme and J. Otte. Rome.
7. Shepon, A., et al. 2016. Energy and protein feed-to-food conversion efficiencies in the US and potential food security gains from dietary changes. Environmental Research Letters, 11:105002.

Pigs in Wendland, Lower Saxony, Germany. The farm is a member of the Neuland (Newland) label, that has high standards in animal welfare and housing

related food poisonings worldwide. Most of these cases are related to the consumption of poultry products.[8] Globally, as mentioned, the increase in poultry consumption is a major component in the overall increase of all meat consumption[9] and, therefore, is likely to increase in importance in relation to the causes of human disease.

The number of chickens, pigs and cattle slaughtered per capita more than tripled between 1961 and 2009, reaching over ten animals slaughtered for every person on Earth in 2009. If this rate continues to hold, **76 billion animals will be slaughtered** to satisfy meat and dairy consumption this year.[10] The ethical dimension of ensuring the wellbeing of all these animals is, therefore, also a very important factor that needs to be considered.

In this report we have not included seafood because our focus has been on the land-based agriculture and food systems. However, fishing is a main driver of biodiversity loss in our oceans. Overfishing and habitat destruction have significantly degraded marine ecosystems worldwide. That said, fishing plays a major role in meeting the basic needs of some of the most vulnerable communities on Earth and makes a critical contribution to global food security.

"If the rate continues to hold, 76 billion animals will be slaughtered to satisfy meat and dairy consumption this year"

Low-impact small-scale fishing has the potential to co-exist with well-preserved ecosystems and abundant fish populations, as well as to support the lives of hundreds of millions of people. Fishing and trade policies should be designed to ensure that priority access to fish resources is granted to small-scale low-impact fishers and to vulnerable communities that depend on seafood to meet their basic nutritional needs. A large majority of global fish stocks have been fully exploited or overfished yet seafood is one of the most internationally traded food commodities. Ensuring food security for vulnerable communities will involve questioning the current appetite for fish in rich societies and diminishing fish consumption, particularly of fish products that are associated with environmental impacts.

8. FAO: Poultry and poultry products - risks for human health.
9. Kearney, J. 2010. Food consumption trends and drivers. Philosophical Transactions of the Royal Society B: Biological Sciences, 365: 2793.
10. Source of estimate is Allievi, F., Vinnari, M. & Luukkanen, J. 2015. Meat consumption and production – analysis of efficiency, sufficiency and consistency of global trends. Journal of Cleaner Production, 92: 142-151. According to FAOSTAT, number of cattle, pig, poultry, sheep and goat slaughtered for meat and dairy production totalled 73.4 billion in 2016. Of those, 66 billion are chicken.

chapter one

The Greenpeace vision for reducing the climate impact of meat and dairy

To meet the goals of the Paris Climate Agreement and ensure a safe climate by 2050, the world needs a revolution in food production, in addition to the decarbonising of all other sectors and increases in carbon sequestration.

To limit the global average temperature increase to 1.5°C, we need to address meat production due to its current large greenhouse gas (GHG) emissions and potentially even larger contributions in the future.[1, 2, 3]

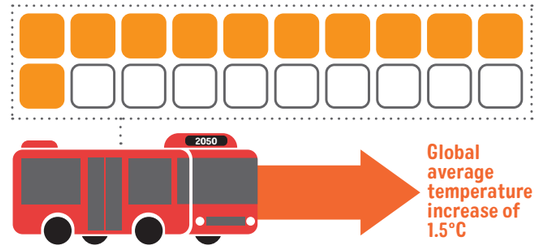
According to recent scenarios on climate gases, emissions from the food system going forward to 2050 have been estimated to reach 20.2 billion tonnes of carbon dioxide equivalent (CO_2e) per year[4], including land-use change, in the baseline scenario.[5, 6]

This means that the GHG emissions from agriculture alone **takes nearly the full 1.5°C target emissions allowance by 2050 for all sectors, including energy, industry, transport and others (21 ± 3 billion tonnes of CO_2e per year).**[7] This fact alone underpins the urgent need, and the opportunity, for tackling food-related emissions, particularly emissions from meat and dairy production.

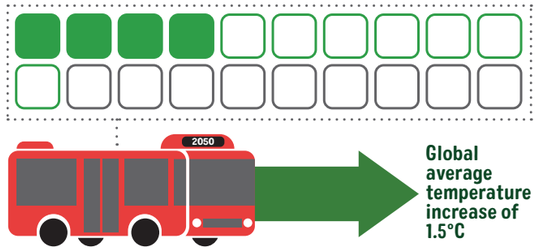
Currently, direct GHG emissions from the agriculture sector account for 24% of all global emissions, and livestock emissions (including land-use change) account for 14%, which is comparable to the emissions from the whole transport sector.[8]

Visualising agricultural emissions

The significance of emission reductions from our current food consumption towards a plant-rich diet can be illustrated very simply. Imagine a bus with 20 seats available for GHGs to limit global warming to 1.5°C by 2050.



Out of these 20 seats, 11 are projected to be taken by the food system, if we continue to increase meat consumption. This only leaves 9 seats for other essential sectors in our economies (energy, industry, transport and beyond). This will be a very crowded bus and probably lead to overflowing and a dangerous journey ahead.



Fortunately, **if we collectively move to a plant-rich diet, we can free up 7 seats on that bus**, thus largely increasing our chances of safely arriving at our destination in 2050. In addition, freeing up those seats will also ensure better human health due to improved diet, and a much better prospect for protecting nature.

Food system emissions in this example do not include land-use change.

Climate emissions from agriculture are projected to continue to increase in absolute as well as relative terms reaching 52% of global emissions in 2050, as population and economic growth brings about increases in food production and waste, as well as shifting diets towards those that are meat-heavy.[9] Technical mitigation potential within agriculture production appears to be less effective than in other sectors, hence the need to address emissions from the food system as a whole, including both the production and consumption of animal products due to their intensity in greenhouse gas emissions.[10]

1. Rogelj, J., et al. 2016. Paris Agreement climate proposals need a boost to keep warming well below 2°C. Nature, 534: 631-639.
2. Bajželj, B., et al. 2014. Importance of food-demand management for climate mitigation. Nature Climate Change, 4: 924-929.
3. Hedenus, F., et al. 2014. The importance of reduced meat and dairy consumption for meeting stringent climate change targets. Climatic Change, 124: 79-91.
4. Billion tonnes or Gigatonnes (Gt) of carbon dioxide equivalent (CO2e) is a unit that combines the emissions of different greenhouse gases into one unit to enable comparison because the impact of different greenhouse gases on the atmosphere is not the same. Methane (CH4) is 25 times more potent than CO2; nitrous oxide is 298 times as potent as CO2. All scenarios are expressed in terms of billions of tonnes of global annual CO2-equivalent emissions per year (Gt CO2e yr–1).
5. The baseline scenario is the Business as Usual (BAU) scenario which assumes no major changes in trajectory, so that normal circumstances can be expected to continue unchanged.
6. Bajželj, B., et al. 2014. Importance of food-demand management for climate mitigation. Nature Climate Change, 4: 924-929. This analysis is for limits between 1.5° and 2° C.
7. Ibid.
8. IPCC 2014: Smith, P., et al. 2014. Agriculture, Forestry and Other Land-Use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
9. Bajželj, B., et al. 2014. Importance of food-demand management for climate mitigation. Nature Climate Change, 4: 924-929.
10. Ibid.

Montbéliarde cattle at an ecological dairy farm in France

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Scientists from the University of Oxford, the Swedish University of Agricultural Sciences, University of Cambridge, University of Aberdeen, University of Minnesota, University of California, Research Institute of Organic Agriculture (FiBL) and the Food and Agriculture Organization, among many other international institutions and authors, have pointed to the climate, environmental, health and economic benefits of drastically reducing livestock production and consumption.[1, 2, 3, 4, 5, 6, 7]

Accordingly, Greenpeace is calling for a global reduction of 50% in production and consumption of animal products by 2050 as compared to the current situation. Achieving this goal is possible under a vision of ecological farming, in other words, a level that ensures food security while protecting climate and biodiversity. This goal is underpinned by a number of scientific models developed by experts in recent years (see details in Chapter 1 of the accompanying longer scientific report available at www.greenpeace.org/livestock_vision).

1. Röös, E., et al. 2017. Greedy or needy? Land-use and climate impacts of food in 2050 under different livestock futures. Global Environmental Change, 47: 1-12.
2. Springmann, M., et al. 2016. Analysis and valuation of the health and climate change cobenefits of dietary change. Proceedings of the National Academy of Sciences, 113: 4146-4151.
3. Schader, C., et al. 2015. Impacts of feeding less food-competing feedstuffs to livestock on global food system sustainability. Journal of The Royal Society Interface, 12.
4. Tilman, D. & Clark, M. 2014. Global diets link environmental sustainability and human health. Nature, 515: 518.
5. Hedenus, F., et al. 2014. The importance of reduced meat and dairy consumption for meeting stringent climate change targets. Climatic Change, 124: 79-91.
6. Popp, A., et al. 2010. Food consumption, diet shifts and associated non-CO2 greenhouse gases from agricultural production. Global Environmental Change, 20: 451-462.
7. Stehfest, E.et al. 2009. Climate benefits of changing diet. Climatic Change, 95: 83–102.

The Greenpeace vision

The Greenpeace vision for ecological farming[8] is of a food system in which there is enough food for all, but one which minimises environmental damage during its production. For livestock, that means animals are reared respectfully and without suffering, using land that is not required for human food production, yet maintaining enough land for biodiversity. Recent scientific models validate this vision of feeding the world with ecologically-grown food. Reducing food waste and meat consumption are imperative for a future based on ecological food and farming.[9]

"Ecological livestock rely only on grasslands, pasture and residues for feed to ensure food security and a healthy planet"

Feeding animals as part of an ecological food and farming system means reducing the amount of land on which they graze and the land dedicated to growing feed, which in turn means dramatically fewer livestock animals than today. This is because land on our planet is finite, and it should be first prioritised for food security and for the health of our planet. Ecological livestock rely only on grasslands, pasture and residues for feed to ensure food security and a healthy planet. This is imperative, because the current food and agriculture system is destroying our climate. At the same time there are more than 800 million people hungry and close to 2 billion overweight.

A 50% reduction in meat and dairy production by 2050 relative to current levels will result in reducing GHG emissions from the agriculture sector by 64% compared to projected emissions under the 2050 baseline trajectories (see Figure 2, based on data for an ecological livestock and healthy diet model from Roos et al (2017)).

The reduction in emissions between the baseline scenario and the Greenpeace goal will be of 7 billion tonnes of CO_2e per year by 2050. This reduction in GHG emissions can be compared to the global limit of emissions for *all sectors* needed for avoiding dangerous climate change, which will be about 20 billion tonnes CO_2e per year in 2050, 10 billion tonnes CO_2e per year in 2070 and reaching 0 billion tonnes CO_2e per year by 2080.[10]

Under the Greenpeace 50% reduction target for meat and dairy, agriculture emissions could be reduced to 4 billion tonnes CO_2eq per year, creating a much more optimistic and feasible scenario for other sectors and for society to limit climate warming to levels that are within safe zones for humanity and biodiversity.

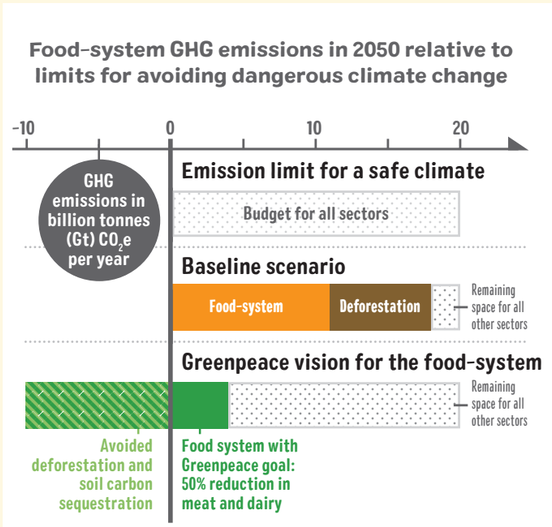

Figure 2. Food-related GHG emissions in 2050 relative to global limit of emissions for all sectors needed for keeping the planet safe from dangerous climate change. A) The GHG budget for all sectors refers to the global amount of emissions, for all sectors combined, that would be consistent with limiting temperature increases to 1.5–2°C. B) GHG emissions under the baseline projections, Business as Usual, for food related emissions, directly from the food system and indirectly from deforestation. C) Emissions under a Greenpeace vision for the food system, including reductions from 50% reduction in meat and dairy production and consumption, plus avoided deforestation and soil carbon sequestration. Source of data: Bajželj, B., et al. 2014. Importance of food-demand management for climate mitigation. Nature Climate Change, 4: 924-929; Röös, E., et al. 2017. Greedy or needy? Land-use and climate impacts of food in 2050 under different livestock futures. Global Environmental Change, 47: 1-12 and IPCC 2014 (Smith, P., et al. 2014. Agriculture, Forestry and Other Land-Use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.)

8. **Ecological farming** ensures healthy farming and healthy food for today and tomorrow, by protecting soil, water and climate. It promotes biodiversity, and does not contaminate the environment with chemical inputs or genetically engineered plant varieties. Ecological farming encompasses a wide range of crop and livestock management systems that seek to increase yields and incomes and maximise the sustainable use of local natural resources whilst minimising the need for external inputs (see Tirado, R. 2015. Ecological farming: the seven principles of a food system that has people at its heart. Greenpeace Research Laboratories Technical Report).
Ecological livestock integrates farm animals as essential elements in the agriculture system; they help optimise the use and cycling of nutrients and, in many regions, provide necessary farm working force. Ecological livestock relies on grasslands, pasture and residues for feed, minimising use of arable land and competition with land for direct human food production, and protecting natural ecosystems within a globally equitable food system (see Tirado, R. & Kruszewska, I. 2012. Ecological Livestock: Options for reducing livestock production and consumption to fit within ecological limits, with a focus on Europe. Greenpeace Research Laboratories Technical Report)
9. Muller, A., et al. 2017. Strategies for feeding the world more sustainably with organic agriculture. Nature Communications, 8: 1290.
10. Rogelj, J., et al. 2016. Paris Agreement climate proposals need a boost to keep warming well below 2 °C. Nature, 534: 631-639 & Bajželj, B., et al. 2014. Importance of food-demand management for climate mitigation. Nature Climate Change, 4: 924-929.

Emissions under the Greenpeace vision for the food system

The ecological livestock model offers large opportunities for reducing climate emissions directly from reducing the number of animals and feed. These reductions could be further enhanced by carbon sequestration in soils and biomass on the land potentially freed from the 50% reduction of current animal production (croplands and grasslands not longer needed for feed production and for fodder or pasture, respectively).

In addition, reducing meat demand will reduce pressure on forested land, and potentially reduce emissions from deforestation. Deforestation emissions[1] can be significant: models estimate that emissions from changes in land-use linked to agriculture can reach approximately 7 billion tonnes of CO_2e per year in the baseline scenario, mostly from Sub-Saharan Africa and Southeast Asia[2]. There is currently no estimation of how much of the deforestation emissions would be potentially avoided specifically by the 50% reduction in meat and dairy production towards 2050. However, livestock is a major driver of land-use change and deforestation.

How much meat and dairy is a 50% reduction by 2050?

Greenpeace's vision of an ecological food system with 50% less meat and dairy delivers a reduction of 50% from current levels of livestock production. This reduction can be translated into how much meat and dairy will be available per capita in 2050 compared to today, and to what is projected to be the global average in 2050.[3]

Under the Greenpeace goal, we estimate a global consumption of meat of 16 kg per capita per year. That relates to approximately 300 grams per capita per week of all meat products (in carcass weight, meaning raw unprocessed products at the point of retail sale). Similarly, for dairy, the 50% reduction results in an estimated global consumption of dairy of 33 kg per capita per year in 2050, which results in 630 grams per capita per week (a glass of milk is roughly 200 grams).

This reduction corresponds to the recommended weekly amount by the World Cancer Research Fund for a healthy diet of a maximum weekly amount of 300 g of red meat. The health implications of meat and dairy consumption are explained further in Chapter 3.[4]

In the year 2030, if we consider a gradual decrease of meat consumption, the estimated consumption would translate into 24 kg per capita per year, compared to a current global average of 43 kg per capita per year, and of 85 kg per capita per year in Western Europe. For dairy in 2030, the target will be at 57 kg of dairy per capita per year. This will allow some room for increases in China, Southeast Asia and Africa; all other regions will have to decrease their average dairy consumption significantly (see Figure 3).

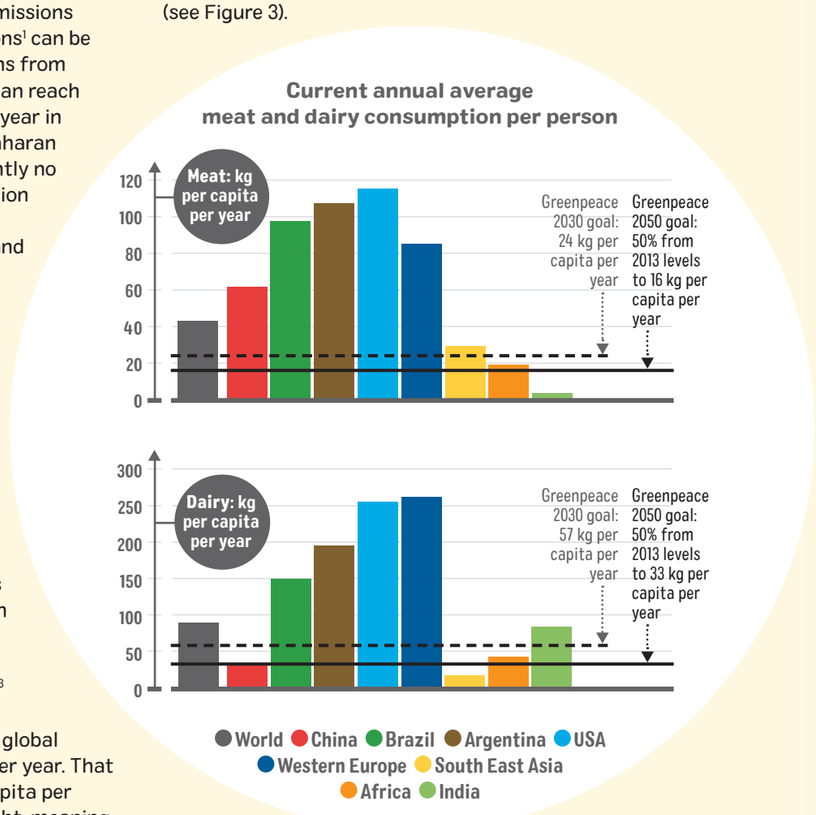

Figure 3. Current average meat and dairy consumption in the world and in China, Brazil, Argentina, USA, Western Europe, Southeast Asia, Africa and India (data for year 2013, the latest current data available from FAOSTAT, 2018). The black lines show Greenpeace goal for reduced consumption by 2050 and midterm goal by 2030. Kg of meat refer to carcass weight, meaning raw unprocessed products at the point of retail sale, as in FAOSTAT.

1. Deforestation can result in carbon that has been stored in the plant material and soil to be released into the atmosphere.
2. Bajželj, B., et al. 2014. Importance of food-demand management for climate mitigation. Nature Climate Change, 4: 924-929) for deforestation number, IPCC 2014 for soil carbon sequestration. This estimates are a broad approximation from previously published values.
3. For details see the accompanying longer scientific report available at www.greenpeace.org/livestock_vision.
4. and in the accompanying longer scientific report, available at www.greenpeace.org/livestock_vision.

Regional considerations on equity and 'common but differentiated' responsibilities
Regional meat consumption trends for the past four decades show the sustained levels of very high meat consumption in the West (for example, USA and Western Europe) and Argentina, compared to the global average and to developing areas (Brazil, China, India, and Southeast Asia and Africa as regions in Figure 4). Future projections indicate how different regions of the world are converging to similar patterns of high meat consumption and Westernised diets.[5]

The Greenpeace vision of ecological livestock would ensure a world without inequalities in access to resources, including access to a healthy and culturally appropriate diet. To achieve an equitable access to animal products, low-income societies in the world would have access to increased consumption of animal products if desired.

This is the shrink and share approach that Greenpeace has advocated for since the publication of the Ecological Livestock report in 2012[6]. However, this will mean drastic cuts in the consumption of animal protein in high meat-consuming parts of society (including affluent sections of society within middle- or low-income countries) and it will allow a moderate increase of consumption in less affluent parts of societies, following the shrink and share principle.

"Under the Greenpeace goal, we estimate a global consumption of meat of 16 kg per capita per year"

Achieving a balanced intake of animal protein among the poorer people in the world will inevitably require drastic cuts in the richer sections of societies, even in developing countries.

As outlined above, a more equitable shared-responsibility future for food security, with climate responsibility, can be achieved if Western regions and the most affluent sections of all societies in the world take the lead in moving towards more plant-rich diets. In addition to climate considerations, the ethical, social, economic, environmental and health pressures resulting from the high consumption of animal products should be equitably shared among different regions of the world and among different sections of our societies.

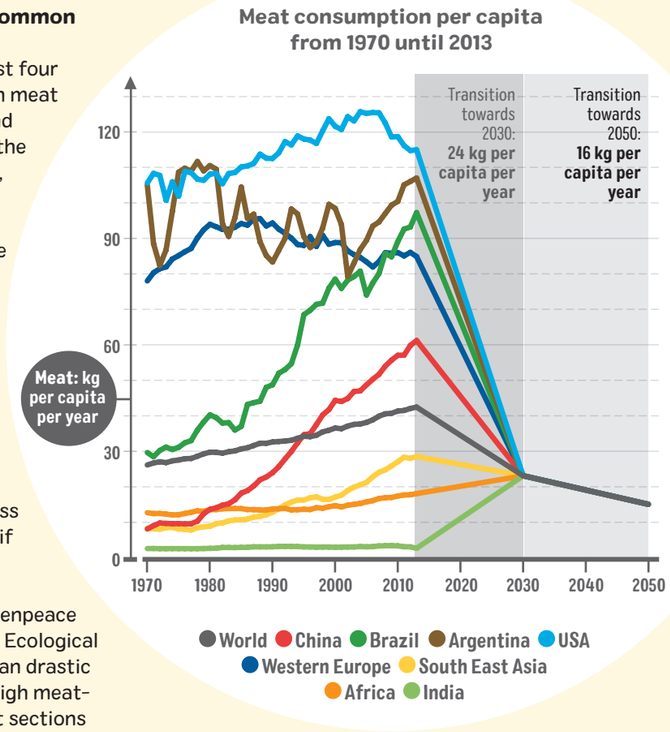

Figure 4. Average meat consumption per person from 1980 until 2013 in the world, and in USA, Argentina, Brazil, Western Europe, China, Southeast Asia, Africa and India (FAOSTAT 2018, latest data for 2013, kg of meat in carcass weight). We indicate in the graph target values for Greenpeace goal towards 2030 and 2050.

The importance of low-impact livestock production systems in rural areas should also be taken into account within this future framework. The adoption of low-meat, plant-rich diets in urban and high-income sections of societies must not translate into an added burden for rural pastoralists and low-impact livestock systems in developing countries. There are options to minimise the climate impacts of those systems.[7] We must find ways to ensure fair rural livelihoods and just economic transitions for livestock producers, particularly in developing regions. At the same time, the environmental, social and animal welfare impacts of any livestock system should be minimised.

The following chapter outlines in greater detail the environmental impacts of meat and dairy production, outlining the urgency to move towards a plant-rich diet to help limit climate change and stem the massive destruction of our ecosystems.

5. Malik, V. S., et al. 2012. Global obesity: trends, risk factors and policy implications. Nature Reviews Endocrinology, 9: 13.
6. www.greenpeace.org/international/en/publications/Campaign-reports/Agriculture/Ecological-Livestock
7. Herrero, M., et al. 2016. Greenhouse gas mitigation potentials in the livestock sector. Nature Climate Change, 6: 452–461.

chapter two

Environmental impacts of meat and dairy

Our planet and its various ecosystems are changing, and food is at the core of those changes.[1,2] Agriculture, and livestock in particular, can be considered as **one of the planet's biggest drivers of global biodiversity loss. In short, what we eat is making our planet sick.** This chapter outlines in more detail how our planet is being pushed to breaking-point by our current food system.

Planetary boundaries

The concept of 'planetary boundaries' is a new approach to quantify the changes in Earth's ability to sustain life, for humans and biodiversity.[3,4] Nine planetary boundaries[5] are thought to encompass the essential planetary processes that keep Earth viable for human life. Some of these boundaries are thought to be beyond safe operating limits as a result of certain human activities. Other boundaries are likely to be transgressed in future if the impacts of human activities continue as projected.

"The impact of meat and dairy production on the planetary processes that maintain life on Earth is so large that it threatens six out of nine key boundaries"

Scientists estimate that **four of the nine planetary boundaries are already significantly transgressed, to a significant extent linked to the environmental impacts of livestock production**: 1) **land system change**, 2) **biosphere integrity or biodiversity loss**, 3) **biogeochemical flow (nitrogen and phosphorus pollution)**, and 4) **climate change**. In addition, a fifth boundary, **freshwater use,** is largely affected by livestock systems globally, and a recent analysis suggests this boundary is also reaching an unsafe zone[6]. The sixth boundary related

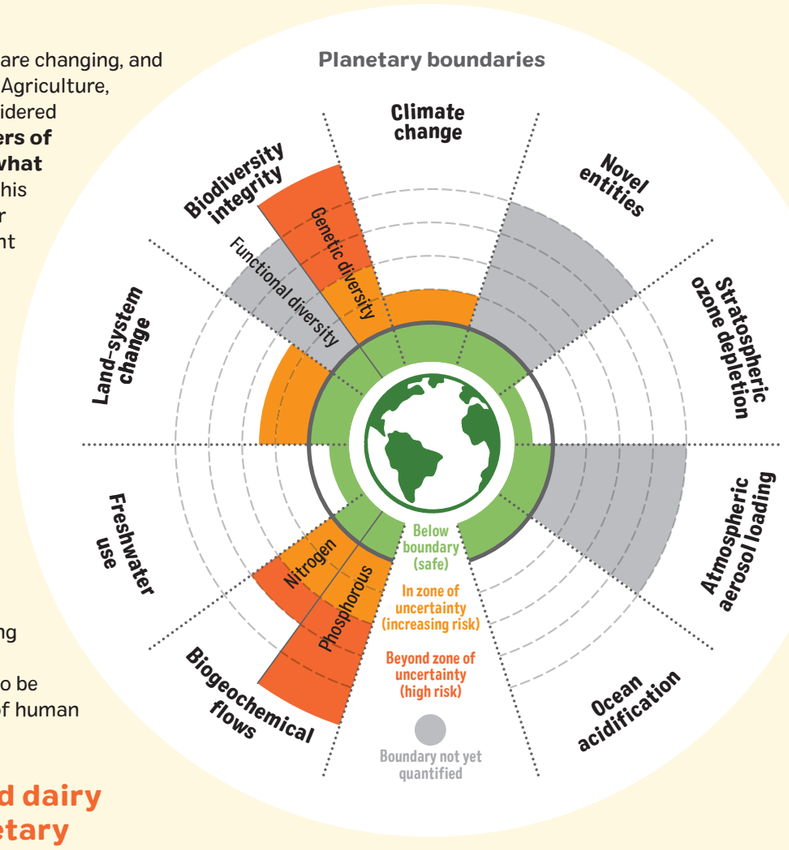

Figure 5. Planetary boundaries: key factors that ensure a habitable planet for humans. Of nine worldwide processes that underpin life on Earth, four have exceeded safe levels – human-driven climate change, loss of biosphere integrity, land system change and the high level of phosphorus and nitrogen flowing into the oceans due mostly to farming. Pollution with nitrogen and phosphorus fertilisers, together with biosphere integrity (biodiversity), are the two planetary boundaries under the high-risk zone for disruption of life on Earth. The novel entities boundary refers to 'new substances, new forms of existing substances, and modified life forms that have the potential for unwanted geophysical and/or biological effects' (e.g. microplastics, nanoparticles or genetically engineered organisms) From Steffen, W., et al. 2015. Planetary boundaries: Guiding human development on a changing planet. Science, 347: 6223. Graphic © theguardian.com (2015).

to **novel entities (or unknown impacts from new substances or life forms) that may affect Earth's ecosystems** holds many links to animal production systems.

The impact of meat and dairy production on the planetary processes that maintain life on Earth is so large that it threatens six out of nine key boundaries. Here we outline the main findings from the latest scientific analysis on these livestock-impacted planetary boundaries.

1. Bajželj, B., et al. 2014. Importance of food-demand management for climate mitigation. Nature Climate Change, 4: 924–929.
2. Campbell, B. M., et al. 2017. Agriculture production as a major driver of the Earth system exceeding planetary boundaries. Ecology and Society, 22: 8.
3. Rockström, J., et al. 2009. A safe operating space for humanity. Nature, 461: 472–475.
4. Steffen, W., et al. 2015. Planetary boundaries: Guiding human development on a changing planet. Science, 347: 6223.
5. Planetary boundaries describe the systems that are vital for human existence on Earth and aim to quantify the current position in 'operating space' within them – from healthy to beyond the safe limits. Nine planetary boundaries have been described so far: 1) land system change, 2) biosphere integrity or biodiversity loss, 3) biogeochemical flow (nitrogen and phosphorus pollution), 4) climate change, 5) freshwater use, 6) novel entities, 7) ocean acidification 8) stratospheric ozone depletion and 9) atmospheric aerosol loading.
6. Campbell, B. M., et al. 2017. Agriculture production as a major driver of the earth system exceeding planetary boundaries. Ecology and Society, 22: 8.

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Land system change

Livestock production is thought to be the single most powerful driver of land system change.[1] The expansion of grazing and cultivation of land on which to grow feed is often at the expense of native forest, grasslands or savannas.[2] During the 50-year period from 1960 to 2011, the production of animal products was responsible for 65% of global land-use change and the expansion of cultivated land.[3] Removing natural forest, savanna and grasslands can irreversibly change entire ecosystems (including changes in species compositions) and affect global carbon cycling, hydrological cycles, local weather systems and other processes.

Estimates of the total area of agricultural land used to feed livestock (grazing and grain) vary. Some scientists have calculated the land for both grazing and feedstock to be 2.5 billion hectares, which is approximately half of all global agricultural land.[4] Almost 2 billion hectares of this was reported as land specifically for grazing livestock.[5]

The land area required for livestock production (crop and pasture land) was estimated to be approximately 75–80% of all agricultural land (Foley *et al.*, 2011 report 75%, Stoll-Kleemann and O'Riordan, 2015 report 80%).[6, 7] Total land used for livestock grazing equates to around 26% of the terrestrial surface of the planet.

Beef production requires more land than other meats according to many theoretical models. The land required for beef is 28 times greater than for dairy, pork, poultry and eggs combined.[8] Beef production requires a particularly high consumption of feed (grazing and feed) when compared to other meats available for human consumption, such as poultry.[9]

However, shifting our diets from one type of meat to another may not significantly reduce environmental impacts of our food because models do not always take into account the need for external inputs (for example fertilisers for feed) and the many negative consequences of intensive pork and poultry production. For example, European pork production may cause damage to the environment that values around 1.9 EUR per kg of pork in terms of eutrophication, acidification, land-use and GHGs.[10]

Globalisation connects people and goods around the world, and the impact of meat and dairy production is now not limited to the country of its consumption. The land required for meat and dairy consumed in one country is often at the expense of native habitats in other regions of the world.[11] Countries no longer consume in isolation, and a positive way forward for the future is to take a global approach to reducing the environmental impacts of our dietary choices.

1. Machovina, B., et al. 2015. Biodiversity conservation: The key is reducing meat consumption. Science of the Total Environment, 536: 419–431.
2. Stoll-Kleemann, S. & Schmidt, U. J.. 2017. Reducing meat consumption in developed and transition countries to counter climate change and biodiversity loss: a review of influence factors. Regional Environmental Change, 17: 1261–1277.
3. Alexander, P., et al. 2015. Drivers for global agricultural land-use change: The nexus of diet, population, yield and bioenergy. Global Environmental Change, 35: 138–147.
4. Mottet, A., et al. 2017. Livestock: On our plates or eating at our table? A new analysis of the feed/food debate. Global Food Security, 14: 1–8.
5. Ibid

6. Foley, J. A., et al. 2011. Solutions for a cultivated planet. Nature, 478: 337–342.
7. Stoll-Kleemann, S. & Schmidt, U. J.. 2017. Reducing meat consumption in developed and transition countries to counter climate change and biodiversity loss: a review of influence factors. Regional Environmental Change, 17: 1261–1277.
8. Eshel, G., et al. 2014. Land, irrigation water, greenhouse gas, and reactive nitrogen burdens of meat, eggs, and dairy production in the United States. Proceedings of the National Academy of Sciences, 111: 11996–12001.

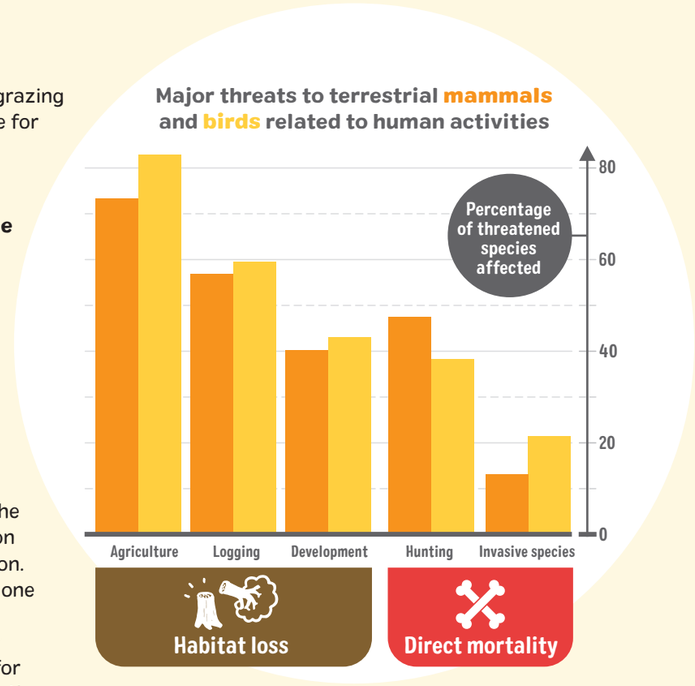


Figure 6. Major threats to terrestrial mammals and birds related to human activities, separated by the mechanism of threat (habitat loss or direct mortality). Categories are aggregations of various stresses and threats, as defined by the IUCN. Reprinted by permission from Springer Nature. Tilman, D., Clark, M., William, D., Kimmel, K., Polasky, S., Packer, C. 2017. Future threats to biodiversity and pathways to their prevention. Nature, 546: 73–81.

Biodiversity loss

Many scientists are concerned that the Earth is now undergoing a sixth mass extinction.[12] Species extinction rates are now more than 1,000 times higher that of natural rates in the absence of human activities.[13, 14, 15]

We also know that global land-use change is associated with this widespread biodiversity loss. There is a strong correlation between the intensity of agricultural land-use and the loss of species. Around 80% of all threatened terrestrial bird and mammal species are threatened by agriculturally driven habitat loss.[16]

Changes in human diets towards more plant-based foods could reduce around 20–40% of the projected increase in extinction risk by 2060 for medium- and large-bodied species of birds and mammals.[17]

Examples of livestock production, particularly cattle grazing, directly interacting with wild species are numerous and date back several decades.[18, 19] Livestock grazing has long been known to lower population densities for a wide variety of species, disrupting nutrient cycling, altering freshwater systems and changing ecological community organisation.[20] In one example, 80% of the decline in vegetation in the Mongolian steppe has been attributed to overgrazing by livestock.[21] In a 10-year experimental study interactions between species were monitored during a number of livestock grazing treatments.[22] Higher stocking densities led to changes in ecosystem dynamics across all trophic levels with significant effects on plant and arthropod (spider) densities, breeding bird territories, vole population cycles and the activity of a top predator (red fox).

9. Ibid.
10. Nguyen, T. L. T., et al. 2012. Environmental costs of meat production: The case of typical EU pork production. Journal of Cleaner Production, 28: 168–176.
11. Yu, Y., et al. 2013. Tele-connecting local consumption to global land-use. Global Environmental Change, 23: 1178–1186.
12. The Earth is currently experience the worst loss of species since the loss of the dinosaurs 65 million years ago.
13. Biodiversity at any given time in the absence of human impacts is the balance of speciation and extinctions. The 'background rate' for extinction refers to this natural rate in the absence of human activities.
14. Barnosky, A. D., et al. 2011. Has the Earth's sixth mass extinction already arrived? Nature, 471: 51–57.
15. Joppa, L. N. et al. 2016. Filling biodiversity threat gaps. Science, 352: 416–418.
16. Tilman, D., et al. 2017. Future threats to biodiversity and pathways to their prevention. Nature, 546: 73–81.
17. Ibid.

18. Taylor, D. M. 1986. Society for range management effects of cattle grazing on passerine birds nesting in riparian habitat. Journal of Range Management, 39: 254–258.
19. Knapp, R. A., & Matthews, K. R. 1996. Livestock grazing, golden trout, and streams in the golden trout wilderness, California: Impacts and management implications. North American Journal of Fisheries, 16: 805–820.
20. Fleischner, T. L. 1994. Ecological costs of livestock grazing in western North-America. Conservation Biology, 8: 629–644.
21. Hilker, T., et al. 2014. Satellite observed widespread decline in Mongolian grasslands largely due to overgrazing. Global Change Biology, 20: 418–428.
22. Evans, D. M., et al. 2015. The cascading impacts of livestock grazing in upland ecosystems: a 10-year experiment. Ecosphere, 6: 42.

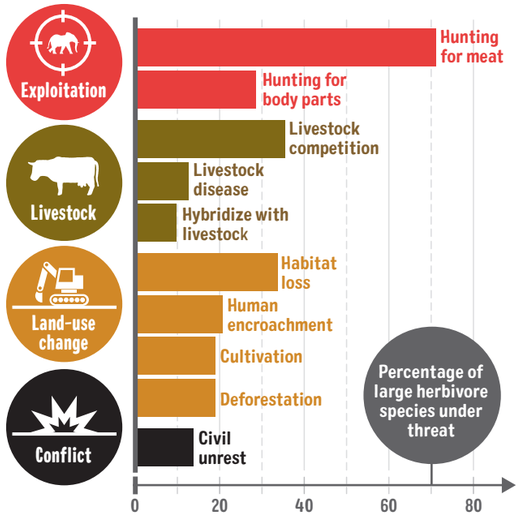


Figure 7. Threats faced by large herbivores globally. Threats faced by each species were categorized using information in the IUCN Red List species fact sheets. The total adds up to more than 100% because each large herbivore species may have more than one existing threat. From: Ripple, W. J., et al. 2015. Collapse of the world 's largest herbivores. Science Advances, 1: 1–12. [with permission/copyright]

Livestock production is also contributing to the loss of both the world's most iconic large carnivores and herbivores, leading to widespread ecosystem imbalance. Livestock production has been implicated as one of the key drivers of loss of large carnivores (for example wolves, bears and large cats) as a result of human persecution. Large carnivores exert strong regulatory effects on ecosystems and their loss can mean that systems become unbalanced.[1] Many large herbivores (for example, rhino, hippos, elephants and tapirs) are also globally threatened and livestock production in many regions can result in competition for grazing, water, a greater risk of disease transmission and hybridisation.[2, 3]

The loss of native habitat is the principal driver of biodiversity loss. Large-scale monocultures (whether crops or livestock) can drive species losses because connectivity between fragments of native habitat is not possible for species that are not able to bridge distances through dispersal.

1. Ripple, W. J., et al. 2014. Status and ecological effects of the world's largest carnivores. Science, 343: 1241484–1241484.
2. Mallon, D. P., & Zhigang, J. 2009. Grazers on the plains: Challenges and prospects for large herbivores in Central Asia. Journal of Applied Ecology, 46: 516–519.
3. Ripple, W. J., et al. 2015. Collapse of the world 's largest herbivores. Science Advances, 1: 1–12.

Nitrogen and phosphorus pollution of water bodies (biogeochemical flows)

Crop and livestock production also exert profound changes to the global nitrogen and phosphorus cycles. The use of both nutrients in farming is highly inefficient.

Phosphorus and nitrogen naturally limit growth for aquatic organisms (both in freshwater and the coastal oceans). When these nutrients are not limited, and the levels of nitrogen and phosphorus are high, dominant species of algae can increase in abundance rapidly and form a 'bloom'. In a bloom, a large amount of algae grow and die. As the algae decompose, oxygen is quickly depleted. Oxygen is not replenished quickly enough, and when oxygen is depleted in water, few species other than certain microbes can survive. Thus, these areas become 'dead zones' that are devoid of most life (often these are also termed hypoxic or anoxic areas).

Though some dead zones occur through natural processes, it is thought that since the 1960s the number has approximately doubled every 10 years. The number of dead zones has increased by 75% since 1992, with more than 600 systems currently recorded.[4, 5, 6] The consequences of human-related dead zones are widespread and economically costly. Fisheries are notably affected by the consequences of low-oxygen zones, where fish stocks can suffer from die-offs, reduced growth rates, increased aggregation and predation pressures, or from the need to move to avoid hypoxic areas.[7] However, quantifying the economic

"The number of dead zones has increased by 75% since 1992, with more than 600 systems currently recorded"

consequences of a die-off is difficult and teasing out the possible contribution from human activities such as livestock production is even more difficult.

Different livestock production systems contribute differing quantities of nutrient pollution to aquatic and marine ecosystems. **Manure management in all livestock systems, and for all meat types, is often the largest contributor to eutrophication[8] of**

4. Diaz, R. J., & Rosenberg, R. 2008. Spreading Dead Zones and Consequences for Marine Ecosystems. Science, 321: 926–929.
5. Díaz, R. J., & Rosenberg, R. 2011. Introduction to environmental and economic consequences of hypoxia. International Journal of Water Resources Development, 27: 71–82.
6. Ripple, W. J., et al. 2017. World Scientists' Warning to Humanity: A Second Notice. BioScience 67: 1026–1028.
7. Díaz, R. J., & Rosenberg, R. 2011. Introduction to environmental and economic consequences of hypoxia. International Journal of Water Resources Development, 27: 71–82.
8. This is the over-enrichment of nutrients in aquatic (freshwater and marine) systems that can cause algal blooms and low oxygen levels.

Pig fattening in intensive animal farming in Germany

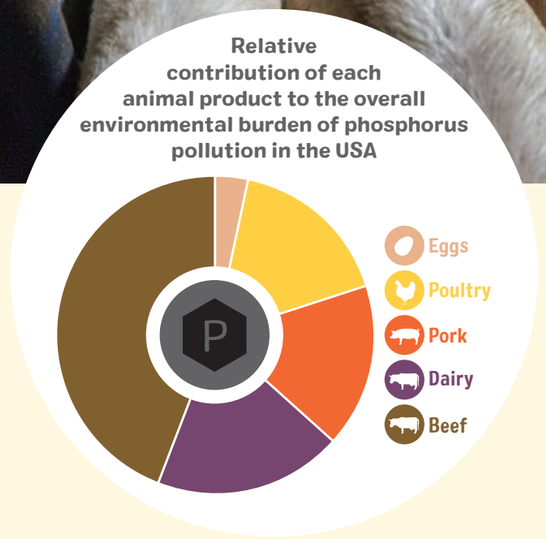


Figure 8. Relative contribution of each animal product to the overall environmental burden of phosphorus pollution in the USA. Figure adapted from Metson, G. S., et al. 2014. Phosphorus is a key component of the resource demands for meat, eggs, and dairy production in the United States. Proceedings of the National Academy of Sciences, 111 :E4906–E4907. (with permission from PNAS).

freshwater and coastal systems.[9] Fertilisers used to produce animal feed, such as corn, can also be a problem. Beef production systems are known to contribute large quantities of nutrients to the environment, but industrial-scale poultry and pig production systems are also greatly responsible for nutrient pollution in both surface and groundwater.[10, 11]

9. Huerta, A. R., et al. 2016. Environmental impact of beef production in Mexico through life cycle assessment. Resources, Conservation and Recycling, 109: 44–53.
10. Zonderland-Thomassen, M. A., et al. 2014. Water footprint of beef cattle and sheep produced in New Zealand: Water scarcity and eutrophication impacts. Journal of Cleaner Production, 73: 253–262.
11. Mallin, M. A., et al. 2015. Industrial swine and poultry production causes chronic nutrient and fecal microbial stream pollution. Water, Air, and Soil Pollution, 226: 407.

Freshwater use

Globally, the total water footprint for animal production accounts for 29% of the water footprint of all agricultural production, between 1996 and 2005 this was 2,422 billion cubic metres per year 87.2% green (rainwater), 6.2% blue (surface and groundwater) and 6.6% grey water (freshwater that is required to assimilate pollutants).[12] The majority (98%) of the total water footprint comes from growing the feed that the animals consume. Different animal products have different water footprints, with a range of environmental impacts.

The future growth of livestock production is likely to significantly increase consumption of water due to the extra demand to grow crops used to feed livestock.[13]

From a freshwater perspective, it is more efficient to obtain calories, protein and fat from plant products rather than animal products, though the types of proteins and fats will differ between these two types of resources. **Per gram of protein, the water footprint of beef is six times larger than for pulses.[14] Some studies suggest that if industrialised countries moved towards a vegetarian diet, the food-related water footprint of humanity could be reduced by around 36%.[15]**

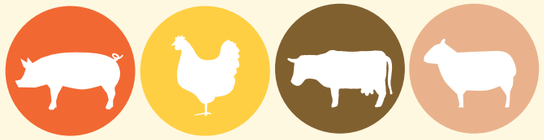
12. Mekonnen, M. M., & Hoekstra, A. Y. 2012. A Global Assessment of the Water Footprint of Farm Animal Products. Ecosystems, 15: 401–415.
13. Campbell, B. M., et al. 2017. Agriculture production as a major driver of the earth system exceeding planetary boundaries. Ecology and Society, 22: 8.
14. Mekonnen, M. M., & Hoekstra, A. Y. 2012. A Global Assessment of the Water Footprint of Farm Animal Products. Ecosystems, 15: 401–415.
15. Hoekstra, A. Y. 2012. The hidden water resource use behind meat and dairy. Animal Frontiers, 2: 3–8.

Chicken farm in Northern Germany. 30,000 male and female chickens of the breed "Ross" are fattened in this north German farm within 35 days to a weight of 2 kg

© Fred Dott / Greenpeace

Novel entities: possible future impacts on humans and the environment

There are other, much more difficult to quantify issues that may impact on the environment in future. These 'novel entities' are new substances, new forms of existing substances and modified life-forms that have the potential for unwanted effects that may destabilise planetary boundaries.[1] Some of these unwanted effects could be attributed to livestock production, including the impact of pollution, diseases, antimicrobial resistance and gene-editing, in ways that are difficult to predict in future.



"The intensification of livestock farming has, in some cases, been linked to the emergence of food-borne pathogens of humans"

Livestock production contributes to widespread chemical pollution. For example, when pesticides are used in feed crop production some of these highly biologically active chemicals can be persistent in ecosystems. Stehle and Schulz (2015) analysed global insecticide concentrations and found that concentrations of 50% of the insecticides detected exceeded local regulatory thresholds.[2] Not all of these insecticides can be attributed to the production of livestock, but it shows that industrial agriculture is clearly polluting Earth's ecosystems.

Another aspect to address is the persistence of certain diseases at the livestock–wildlife–human interface that can affect both farmers and wildlife.[3, 4] Livestock are known to be reservoirs of disease that can be harmful to wild herbivores.[5] The intensification of livestock farming has, in some cases, been linked to the emergence of food-borne pathogens of humans (zoonoses), such as *Cryptosporidium parvum*, diarrheagenic *Escherichia coli*, *Listeria monocytogenes*, *Campylobacter jejuni*.[6]

Moreover, the routine, extensive and increasing use of antimicrobial products in livestock production has also been recognised as an important challenge for animal and human medicine.[7] Antimicrobial resistance is the accumulation of certain genes within microbial populations that increase survival of that microbe species or population. Strains of livestock and human pathogens, such as *Campylobacter* spp. and *Salmonella* spp., that are resistant to treatment are now commonplace.

Livestock are now the focus of gene-editing research and development using the new wave of genomic tools, such as transcription activator-like effector nucleases (TALEN) and clustered regularly interspaced short palindromic repeats/Cas9 system (CRISPR/Cas9). These tools allow researchers to engineer livestock for disease resistance[8], to produce more meat[9], more desirable milk products[10, 11] and a number of pharmaceutical products.[12] Gene-editing is also being investigated as a tool to make livestock less environmentally damaging, with fewer nutrient emissions. Like any new technology in early development, the positive impacts are often highlighted while the negative impacts are ignored or not yet researched. For Greenpeace, strict adherence to science and the precautionary principle is essential to avoid generating yet more unintended negative consequences.[13]

This chapter clearly outlines how the effects of industrialised agriculture is not only polluting our planet but also pushing multiple planetary boundaries to the limit, while accelerating the next planetary mass extinction. The urgency for action to change our food system has never been clearer. This is why Greenpeace is calling for a food system in which there is not only enough food for all, but one that minimises environmental damage during its production. For livestock, that means that animals are reared respectfully and without suffering, using land that is not required for human food production, while maintaining enough land for biodiversity. In the following chapter we will examine the extensive effects that the current farming systems have on human health.

1. Steffen, W., et al. 2015. Planetary boundaries: Guiding human development on a changing planet. Science, 348: 1259855.
2. Stehle, S., & Schulz, R. 2015. Agricultural insecticides threaten surface waters at the global scale. Proceedings of the National Academy of Sciences, 112 :5750–5755.
3. Ripple, W. J., et al. 2015. Collapse of the world 's largest herbivores. Science Advances, 1: 1–12.
4. Grace, D., et al. 2017. Poor livestock keepers: ecosystem-poverty-health interactions. Philosophical transactions of the Royal Society of London Series B, 372: 20160166.
5. Ripple, W. J., et al. 2015. Collapse of the world 's largest herbivores. Science Advances, 1: 1–12.
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7. Van Boeckel, T. P., et al. 2015. Global trends in antimicrobial use in food animals. Proceedings of the National Academy of Sciences, 112: 5649–5654.
8. Bishop, S. C., & Wooliams, J. A. 2014. Genomics and disease resistance studies in livestock. Livestock Science, 166: 190–198.
9. Proudfoot, C., et al. 2015. Genome edited sheep and cattle. Transgenic Research, 24: 147–153.
10. Świątkiewicz, S., et al. 2015. The use of genetic engineering techniques to improve the lipid composition in meat, milk and fish products: a review. Animal, 9: 696–706.
11. Whitelaw, C. B. A., et al. 2016. Genetically engineering milk. Journal of Dairy Research, 83: 3–11.
12. Bertolini, L., et al. 2016. The transgenic animal platform for biopharmaceutical production. Transgenic Research, 25: 329–343.
13. EEA 2013. Late lessons from early warnings: science, precaution, innovation. European Environment Agency. EEA Report No 1/2013.

chapter three

Human health impacts of meat and dairy

This chapter outlines research that clearly demonstrates that the consumption of certain meat products is associated with a number of adverse effects on human health. Healthy diet guidelines are often not updated with current evidence or dietary trends, and very seldom include environmental considerations.

In the past few years, some countries have recommended reducing red meat intake, which is positive for environmental reasons as well as health ones. However, if those countries recommend substituting red meat with other meats, such as poultry, there will still be disproportionate negative environmental impacts compared with plant food types including legumes, vegetables and nuts.[1] In addition, increasing poultry consumption by substituting red meat with white meat, might lead to other health risks, like food bacterial infections.

"Research suggests that eating fruits, vegetables, legumes, whole grains and/or nuts is associated with beneficial health outcomes"

However, replacing beef with vegetables is far more beneficial. Research suggests that eating fruits, vegetables, legumes, whole grains and/or nuts is associated with beneficial health outcomes such as reduced incidence of coronary heart disease, diabetes, stroke and certain types of cancer. In addition, a diet low in meat and dairy will be far better for the environment.

In the following sections we summarise evidence on the health effects of consuming all types of meat and dairy, keeping in mind that the current available studies are skewed towards red meat. Many studies to date have focused on the consumption of red meat (beef, pork, lamb, mutton or goat meat), which has a different biological composition in comparison to white meat (chicken, turkey, rabbit). Some researchers[2] have suggested that more research should be carried out to investigate whether there are associations between eating white meat and early mortality. Others conclude that further studies may be needed to evaluate the health outcomes in relation to the consumption of eggs and dairy products.

We also look at the wide ranging and expanding body of literature that suggests there are known and potential impacts upon human health that stem from livestock production, particularly that of intensive industrial systems. We present findings from the literature on: 1) The consumption of different meat types and their known impact on human health; 2) Some of the common foodborne diseases that are associated with meat and; 3) The direct and indirect effects of livestock production on human health.

Healthy and unhealthy foods (Imamura et al. 2015)

Diet component	Why 'healthy'/'unhealthy'	
Fruits (100g/serving)	↓ Coronary heart disease (CHD), ↓ oesophageal cancer, ↓ lung cancer, ↓ stroke	HEALTHY
Vegetables, including legumes (100g/serving)	↓ CHD, ↓ oesophageal cancer, ↓ stroke	HEALTHY
Nuts/seeds (100g/serving)	↓ CHD, ↓ diabetes	HEALTHY
Wholegrains (50g/serving)	↓ CHD, ↓ diabetes	HEALTHY
Seafood (100g/serving)	↓ CHD, ↓ stroke	HEALTHY
Red meat, unprocessed (100g/serving)	↑ Diabetes, ↑ colorectal cancer	UNHEALTHY
Processed meat (50g/serving)	↑ CHD, ↑ diabetes, ↑ colorectal cancer	UNHEALTHY

Table 1: A table showing foods that can have an impact on the risk of developing non-communicable diseases (CHD is an abbreviation of coronary heart disease). From: GLOPAN, 2016. Global Panel on Agriculture and Food Systems for Nutrition. 2016. Foresight report: Food systems and diets: Facing the challenges of the 21st century. London, UK. 132 pp.

1. Behrens, P. et al. 2017. Evaluating the environmental impacts of dietary recommendations. Proceedings of the National Academy of Sciences, 114: 13412–13417.
2. Abete, I., et al. 2014. Association between total, processed, red and white meat consumption and all-cause, CVD and IHD mortality: a meta-analysis of cohort studies. British Journal of Nutrition, 112: 762–775.

Cancer

The evidence associating red meat intake with adverse health effects is so strong that in 2015 the International Agency for Research on Cancer classified red meat as 'probably carcinogenic to humans' and processed meat as a 'carcinogenic to humans'.[1, 2] This evaluation was based on a report compiled by a working group of 22 experts from ten countries who assessed more than 800 studies. The conclusions of the evaluation stated that every 50g daily intake of processed meat increases the risk of colorectal cancer by 18% – in short, eating processed meat causes colorectal cancer.[3, 4]

Results of other analyses associate eating red and processed meat with an increased risk of developing some cancers, including colorectal, stomach, liver, lung, bladder, pancreas and oesophagus .[5, 6, 7] One study found that consuming one serving of processed meat every day was associated with an 8% increase in the risk of death from cancer, when compared to those with little to no consumption of processed meat.[8]

In contrast, the consumption of fruits, vegetables, legumes, whole grains and/or nuts is associated with reduced incidence of coronary heart disease, diabetes, stroke and certain types of cancer.[9, 10]

Obesity and diabetes

A global rise in the consumption of meat, fats and refined sugar is contributing to the increased prevalence of obesity and chronic, non-communicable diseases such as type II diabetes, cardiovascular disease and cancers in low-, middle- and high-income countries.

The consumption of processed and unprocessed red meat, in particular, has been linked with a rise in the global prevalence of obesity[11] and an increased risk of developing type II diabetes.[12] Research suggests that eating only one serving per day of unprocessed, processed and total red meat is associated with an increased risk of developing type II diabetes. On the other hand, adopting a plant-based diet brings an approximately 40% reduction in risk of developing type II diabetes.[13]

Cardiovascular disease

Stroke, coronary heart disease, aortic disease and peripheral arterial disease are all symptoms of cardiovascular disease. Consumption of both processed meat and unprocessed red meat has been associated with an increased risk of cardiovascular, all-cause and cancer mortality in studies that have followed large populations over years or decades. One study found that consumption of red and processed meat in women is associated with an increased risk of developing coronary heart disease.[14] Consumption of **processed and unprocessed red meat was also associated with an increased risk of total stroke and ischemic stroke** in research that included a total of 329,495 participants.[15]

"A global rise in the consumption of meat, fats and refined sugar is contributing to the increased prevalence of obesity and chronic, non-communicable diseases"

The National Institutes of Health-AARP Diet and Health Study analysed ten years of data (1995 to 2005) from almost half a million USA residents (age 50 to 71 at the start of the study).[16] This study found that early death from cardiovascular disease could be reduced if the people in the group that consumed the most red meat (median 62.5 g per day), reduced their red meat intake to the level of those who ate the least red meat (median 9.8 g per day): by making this dietary adjustment, 11% of deaths in men and 16% of premature deaths in women could be prevented.

1. http://www.who.int/features/qa/cancer-red-meat/en/
2. IARC. 2015. IARC Monographs evaluate consumption of red meat and processed meat. International Agency for Research on Cancer. Press release No. 240. World Health Organisation (2015).
3. Bouvard, V., et al. 2015. International Agency for Research on Cancer Monograph Working Group. Carcinogenicity of consumption of red and processed meat. Lancet Oncology, 16: 1599–1600.
4. IARC. 2015. IARC Monographs evaluate consumption of red meat and processed meat. International Agency for Research on Cancer. Press release No. 240. World Health Organisation.
5. Boada, L.D., et al. 2016. The impact of red and processed meat consumption on cancer and other health outcomes: epidemiological evidences. Food and Chemical Toxicology, 92: 236–244.
6. Lippi, G.,et al. 2016. Meat consumption and cancer risk: a critical review of published meta-analyses. Critical Reviews in Oncology/Hematology, 97: 1–14.
7. Wang, X., et al. 2016. Red and processed meat consumption and mortality: dose-response meta-analysis of prospective cohort studies. Public Health Nutrition, 19: 893–905.
8. Ibid.
9. GLOPAN, 2016. Global Panel on Agriculture and Food Systems for Nutrition. 2016. Foresight report: Food systems and diets: Facing the challenges of the 21st century. London, UK. 132 pp.
10. Wei, H., et al. 2016. Whole-grain consumption and the risk of all-cause, CVD and cancer mortality: a meta-analysis of prospective cohort studies. British Journal of Nutrition, 116: 514–25.
11. Rouhani, M., et al. 2014. Is there a relationship between red or processed meat intake and obesity? A systematic review and meta-analysis of observational studies. Obesity Reviews, 15: 740–748.
12. Pan, A., et al. 2011. Red meat consumption and risk of type 2 diabetes: 3 cohorts of US adults and an updated meta-analysis. American Journal of Clinical Nutrition, 94: 1088–1096.
13. Tilman, D., & Clark, M. 2014. Global diets link environmental sustainability and human health. Nature, 515: 518–522.
14. Bernstein, A. M., et al. 2010. Major dietary protein sources and the risk of coronary heart disease in women. Circulation, 122: 876–883.
15. Kaluza J, et al. 2012. Red meat consumption and risk of stroke: a meta-analysis of prospective studies. Stroke, 43: 2556–60.
16. Sinha, R., et al. 2009. Meat intake and mortality: a prospective study of over half a million people. Archives of Internal Medicine, 169: 562 –571.

Beef and pork on sale in a German supermarket

The consumption of processed and unprocessed red meat, in particular, has been linked with a rise in the global prevalence of obesity

Heart attack

Research in Costa Rica between 1994 and 2004 has shown that people who eat one daily portion of red meat (processed or unprocessed, beef, lamb, pork or veal) were 31% more at risk of heart attack than people who only ate 1.5 portions of any red meat per week.[17] This association between meat and heart attack was found to be stronger in women than men.

A Danish study that followed more than 55,000 men and women age 50–64 for 13.5 years and living in Denmark found that replacing red meat with vegetables or potatoes significantly reduced the risk of heart attack in women.[18]

Diverticulitis

Diverticulitis is a medical condition that occurs in the digestive system, when the diverticula, which are pockets that develop in the lining of the large intestine, become inflamed. A study found that men who ate red meat, particularly unprocessed red meat, were at increased risk of developing diverticulitis.[19] The study included 46,461 USA male health professionals, aged 40–75 when they were first enrolled in the 26-year study (1986–2012).

Chronic liver disease

A large-scale longevity study found an association between the consumption of processed and unprocessed red meat and early mortality.[20] The most significant association was with consumption of red meat, particularly processed red meat, and chronic liver disease**.** The paper analysed data from the NIH–AARP study, which comprised responses from 536,969 people over a 16-year period (a total of 7,540,835 person years of follow-up).

17. Wang, D., et al. 2017. Red meat intake is positively associated with non-fatal acute myocardial infarction in the Costa Rica Heart Study. British Journal of Nutrition, 118 :303–311.
18. Würtz, A. M. L., et al. 2016. Substitution of meat and fish with vegetables or potatoes and risk of myocardial infarction. British Journal of Nutrition, 116: 1602-1610.
19. Cao, C., et al. 2017. Meat intake and risk of diverticulitis among men. Gut Published Online First: 09 January 2017.
20. Etemadi, A., et al. 2017. Mortality from different causes associated with meat, heme iron, nitrates, and nitrites in the NIH-AARP Diet and Health Study: population based cohort study. British Medical Journal 357: j1957.

Chemical compounds associated with meat consumption

Some of the chemical compounds that are found in meat have been associated with adverse human health. For example, some meat-associated compounds, such as polycyclic aromatic hydrocarbons and heterocyclic amines, which form during the cooking of meat, could be carcinogenic to humans.[1] The most common meat-associated compounds are:

- **Glycolylneuraminic acid:** human consumption can lead to chronic inflammation.
- **Heme iron:** over-consumption has been linked to diabetes, cardiovascular disease and cancer.
- **Nitrates and nitrites:** over-consumption may lead to cancer.
- **N-nitroso-compounds (which are added to processed meat) and amines:** may lead to cancer.
- **Saturated fats:** over-consumption may lead to obesity and type II diabetes.

Foodborne diseases

Diseases from foodborne agents can be caused by bacteria, viruses, protozoans, helminths (flatworms or flukes) and chemicals. **In the UK between 2010 and 2015, the most common cause of foodborne illness, like diarrhoeal disease, in meat and non-meat products was the bacteria *Campylobacter* spp., with four of five cases caused by infected poultry.**[2]

The most common cause of foodborne death in the UK according to the UK Food Standards Agency was caused by *Listeria monocytogenes*, a bacterium that is found in unpasteurised milk and cheese, poultry and fish.[3] Other major pathogens in the UK are *Escherichia coli* 0157, which is found in cattle and can be spread by contact with faeces of contaminated animals and in contaminated food, and *Salmonella* spp., which is found in poultry and eggs.

Human health impacts of livestock production

Meat and dairy production has been shown to be associated with antimicrobial resistance[4], zoonotic diseases[5], air pollution due to the release of fine particulate matter ($PM_{2.5}$), and runoff from fertilizers and manure slurry as well as chemicals that can contaminate waterways and coastal oceans.

The best-known example of antimicrobial resistance in livestock production are Livestock Associated Methicillin Resistant *Staphylococcus aureus* (LA-MRSA)[6], which is also known to colonise humans working with animals and may give rise to human infections.[7]

Zoonoses are diseases that can transfer from animals to people. Methods of infection include through contaminated animal products or as airborne particulates. An example of a commonly detected zoonosis is *Taenia solium,* or the pork tapeworm. Infection with the larval form of this parasite (cysticercosis) is considered to be one of the major causes of global foodborne deaths. Larval infection is through ingestion of tapeworm eggs. The adult tapeworm infects humans through consumption of undercooked or uncooked pork infected with the larvae.[8]

Pollution related to livestock production can also negatively impact on human health. Water that has been contaminated with nitrates as a result of agricultural practices can be a particular problem for sensitive groups, for example bottle-fed infants. Excess intake of nitrate and nitrite has been associated with health problems that include bladder, thyroid, colon, kidney, ovarian and gastric cancers, and non-Hodgkin's lymphoma.[9, 10]

"Excess intake of nitrate and nitrite has been associated with health problems that include bladder, thyroid, colon, kidney, ovarian and gastric cancers, and non-Hodgkin's lymphoma"

If humans ingest water that has not been properly treated, there may be an increased risk of microbial contamination. For example, a study in Piedmont, Italy, found that the hepatitis E virus (HEV) can be transmitted in drinking water.[11] The authors of this study hypothesize that the practice of fertilizing cultivated fields with swine manure, common in this area of Italy, may have contaminated groundwater reserves and local fountains where water remains untreated.

Air pollution in areas close to intensive livestock farms can cause poor air quality because of the emission of

1. Wang, X., et al. 2016. Red and processed meat consumption and mortality: dose-response meta-analysis of prospective cohort studies. Public Health Nutrition, 19: 893–905.
2. https://www.food.gov.uk/science/microbiology/campylobacterevidenceprogramme
3. https://www.food.gov.uk/science/microbiology/fds
4. Antimicrobial resistance occurs when microorganisms such as bacteria, viruses, fungi and parasites change in ways that render the medications used to cure the infections they cause ineffective.
5. These are diseases that can be transferred between animals and humans.
6. In some cases can cause small red bumps, rashes or fever. Can be a problem for those with weakened immune systems.
7. Cuny, C., et al. 2015. Livestock associated MRSA: The impact on humans. Antibiotics (Basel), 4: 521-543.
8. WHO. 2015. Healthy diet fact sheet No. 394.
9. McKnight, G. M.,et al. 1999. Dietary nitrate in man: friend or foe? British Journal of Nutrition, 81: 349–358.
10. Santamaria, P. 2005. Nitrate in vegetables: toxicity, content, intake and EC regulation. Journal of the Science of Food and Agriculture, 86: 10–17.
11. Caruso, C. et al. 2017. Hepatitis E Virus: A cross-sectional serological and virological study in pigs and humans at zoonotic risk within a high-density pig farming area. Transboundary and Emerging Diseases, 64: 1443–1453.

Possible routes of transfer of antibiotic resistance from livestock farming to humans.

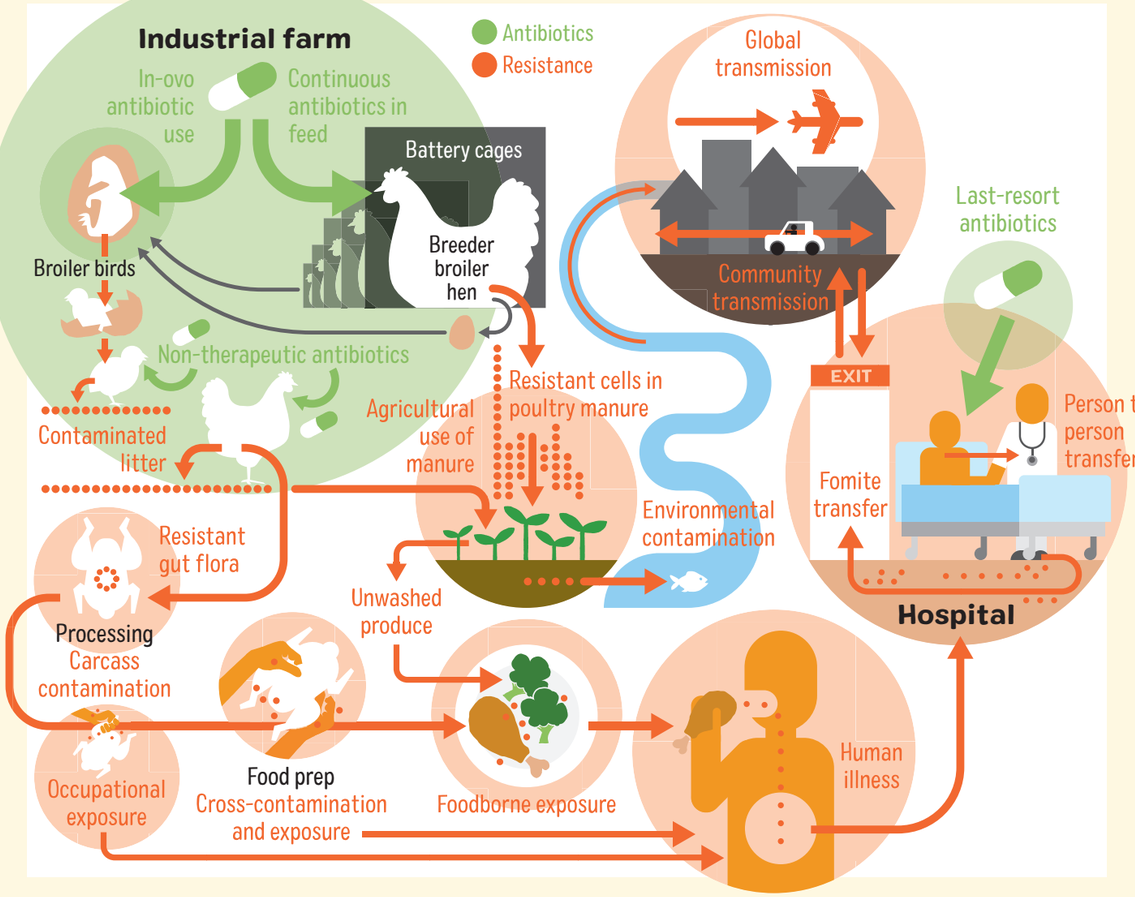

Figure 9: A schematic showing the possible routes of transfer of antibiotic resistance from livestock farming to humans. The figure shows the 'ecosystem' of antibiotic resistance that links antibiotic resistant bacteria in poultry to humans. From: Koch, B., et al. 2017. Food-animal production and the spread of antibiotic resistance: the role of ecology. Frontiers Ecology and Environment, 15: 309–318. Adapted, with permission, from the original figure by Victor O. Leshyk.

coarse and fine dust particles, gases and endotoxins (endotoxins are molecules associated with certain bacteria)**.** Particulate matter that is emitted from farms comprises both organic (dust, animal hair, bedding, feathers, animal feed, viruses, fungi, bacteria) and fine inorganic particles ($PM_{2.5}$) and can lead to health issues for humans. One study found that living in close proximity to intensive livestock farms could adversely affect the respiratory health of local non-farm-working residents (the residents reported asthma-like conditions).[12]

Another longitudinal study of respiratory health monitored 57 school-age children who had been diagnosed with asthma and who lived in a rural area of Washington State, USA, where there is a high number of large-scale farms (dairy and orchards).[13] The study found that increases in $PM_{2.5}$ led to short-term increases in symptoms (including wheezing and waking during the night) of asthma in the children studied. All of these studies illustrate how humans can be adversely affected by livestock farming, without even consuming animal products.

12. Radon, K., et al. 2007. Environmental exposure to confined animal feeding operations and respiratory health of neighboring residents. Epidemiology, 18: 300-308.
13. Loftus, C. et al. 2015. Ambient ammonia exposures in an agricultural community and pediatric asthma morbidity. Epidemiology, 26: 794–801.

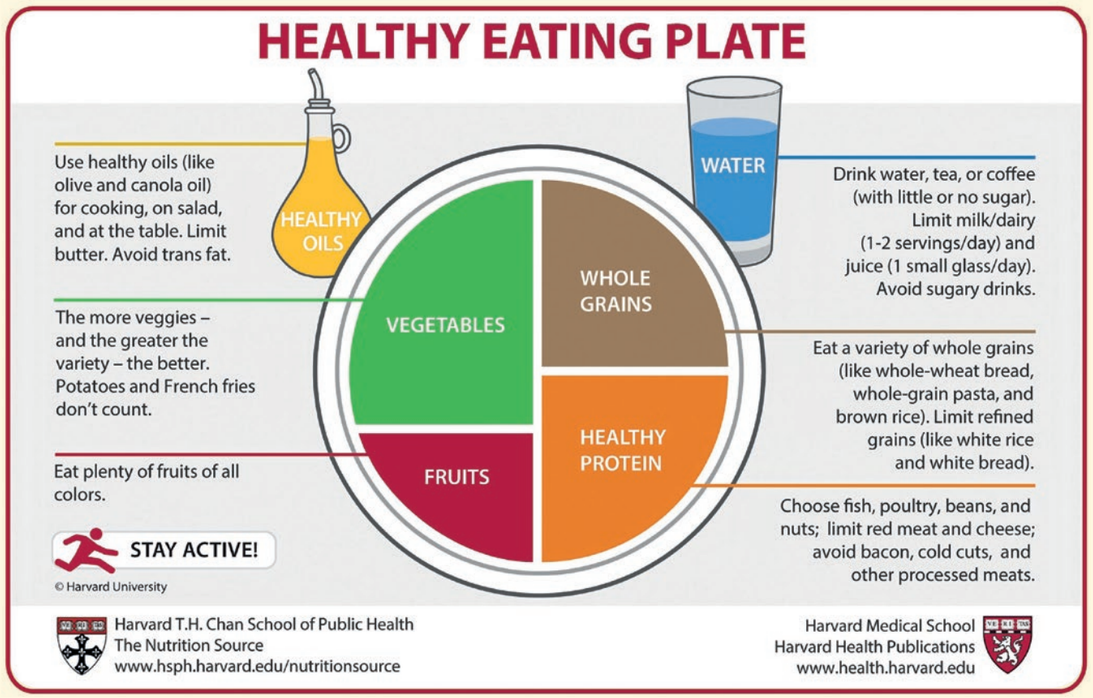

Figure 10: The Harvard Healthy Eating Plate. The Healthy Eating Plate was created by Harvard Health Publishing and nutrition experts at the Harvard School of Public Health. It offers more specific and more accurate recommendations for following a healthy diet than MyPlate, developed by the U.S. Department of Agriculture and the Department of Health and Human Service. In addition, the Healthy Eating Plate is based on the most up-to-date nutrition research, and it is not influenced by the food industry or agriculture policy. Source: https://www.health.harvard.edu/plate/healthy-eating-plate.

A healthy diet?

All of the above analysis clearly demonstrates the adverse effects that current trends in production and consumption of meat and dairy products can have on human health.

Just last year, the World Cancer Research Fund and the American Institute for Cancer Research recommended that diets consist mainly of foods of plant origin with limited intake of foods from animal origin, and suggest a goal for public health is to limit consumption of red meat to less than 300g of cooked meat per week to help protect against colorectal cancer.[1]

According to the Global Burden of Disease (GBD) study, among all forms of malnutrition, **poor dietary habits, particularly low intake of healthy foods, is the leading risk factor for mortality**. It highlights that, "this finding has important implications for national governments and international organisations aiming at ending malnutrition over the next decade, **highlighting the need for comprehensive food system interventions to promote the production, distribution, and consumption of healthy foods across nations**."[2] GBD is the most comprehensive worldwide observational epidemiological study to date. A properly planned vegan diet, in which only plant foods and no animal products are consumed, is appropriate for people at all stages of life and provides all the necessary nutrients, vitamins, minerals and amino acids apart from vitamin B12 (a B12 supplement might be necessary). A balanced lacto-ovo vegetarian diet, plant-based with a moderate intake of eggs and dairy products, is the most common form of plant-based diet and fulfils all nutritional requirements. The lacto-ovo vegetarian diet is safe and healthy for pregnant and breastfeeding women, babies, children, teenagers and seniors.[3]

Our findings on the negative health impacts of high meat consumption and benefits of plant-rich diets underlie the multiple wins that could be realised from Greenpeace's call to drastically reduce the consumption of animal products. Improvements in human wellbeing add to the strong positive impacts on the planet's health.

1. WCRF. 2017. World Cancer Research Fund International/American Institute for Cancer Research. Continuous Update Project: Diet, nutrition, physical activity and the prevention of cancer. Summary of strong evidence.

2. GBD 2016. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet, 390: 1345-1422.

3. For example, see https://www.uvic.ca/services/food/assets/docs/Vegetarian_EatingGuidelines.pdf

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The Sustainable School Lunch Program in Thailand is aimed at promoting kindergarten and primary school lunches that are safe, nutritious, and made from ecological ingredients which are healthy for both for the students and the environment

Farmer Carren Onyango, Collines Otieno (Lucky) and child in a corn field, Lower Nyando - Kisumu County. Farmers in Kenya are effectively applying ecological farming practices that are increasing their ability to build resilience to and cope with climate change

Concluding remarks and recommendations

If we fast forward to 2050, we could find a world where the worst predictions of climate change did not come true. Some of the effects of climate change might be more evident, but we could have avoided the worst. This better future would be the result of our governments, farmers, businesses, school boards, young people and us all, responding decisively to the challenges of climate change and environmental destruction. Responding to this challenge by changing our food, by posing the question of *What to eat?* represents one of the strongest actions we can collectively take.

The evidence drawn together in this report indicates that what we decide to eat, as an individual and as a global society, is one of the most powerful tools we have in the fight against climate change and environmental destruction. Moreover, it is also perhaps the best prevention of some of the leading causes of poor human health and early mortality.

There is mounting scientific evidence pointing to the idea that changing what and how much we eat represents a win–win opportunity with regards to reshaping the current global food system, with substantial benefits for food security, the environment, climate, human health, and even our economies and wellbeing.

Reorganising food systems will not be a quick fix. As we all know, the food system is complex. The real challenge now is to ensure effective and concrete ways to achieve a just transition into a better food system, where a reasonable number of animal products are produced with the land and resources not required for food or nature needs.

Animals play an essential part in agriculture systems. Animals help to optimise the use and cycling of nutrients and, in many regions, are used for necessary farm work, an additional form of income and insurance. Animal welfare also needs to be taken into account when making food choices.

Reducing meat and dairy production will require a just transition where the livelihoods of farmers and rural communities are central to decision making. Unfortunately, the current economic and political system props up and accelerates industrial livestock production. However, science and practice already show that a different food system is possible. Governments and companies need to support a just transition for farmers from industrial meat and dairy production towards mixed ecological livestock and plant crop production

“Science suggests that changing our dietary preferences toward plant-rich diets will reduce environmental costs and feed millions of people with no additional natural resource use”

by shifting subsidies, policies and practices along the whole value chain. There is a need for public finances to support the production of healthy fruits and vegetables from ecological farms and better meat from ecological livestock producers.

To avoid massive environmental consequences, the world needs to drastically reduce, by at least half, current production and consumption of meat and dairy, globally and towards 2050. Science suggests that changing our dietary preferences toward plant-rich diets could feed millions more people while reducing environmental costs.

Now we need more of the world’s economists, politicians, nutritionists, agronomists, development experts, farmers, educators, and many more, to start having open and frank conversations about the issues that will help us get to 2050 with a just food system for humans and the planet.

Less meat to fight climate change

Greenpeace's call for a 50% reduction in production and consumption of animal products by 2050, as compared to the current situation, will result in significant decreases of emissions in terms of climate. Our proposals will lead to a **64% reduction in greenhouse gases relative to a 2050 world that follows current trajectories.** In absolute numbers that is approximately -7 billion tonnes of CO_2e per year by 2050.

This reduction represents 35% of the total amount of climate gases allowed to enter the atmosphere by 2050 for all sectors to meet the Paris Agreement target for avoiding dangerous temperature increase. Thus, it represents a very significant contribution to achieving emissions targets to ensure a safe climate.

Less meat to fight deforestation

If we were to include the potential reduction in indirect emissions from avoided deforestation linked to livestock or feed cropland expansion, and by potential carbon sequestration in soils freed up from grazing or cultivation, the cuts in emissions would be significantly higher. These indirect reductions in emissions could be close to -10 billion tonnes CO_2e per year by 2050. This equals around -7 billion tonnes CO_2e per year from avoided deforestation, and -2.8 billion tonnes CO_2e per year from soil carbon sequestration.[1] This could effectively more than equal the reductions in direct livestock emissions, thus doubling the contribution of avoided or negative emissions.[2]

Fighting deforestation should be a key global priority. Cutting meat and dairy production in half would free many millions of hectares on the planet that would then be available to grow plant food for humans, as well as supporting biodiversity conservation.

1. Bajželj, B., et al. 2014. (Importance of food-demand management for climate mitigation. Nature Climate Change, 4: 924–929) for deforestation number, IPCC 2014 for soil carbon sequestration. This estimates are a broad approximation from previously published values.
2. It should be noted that these indirect land-use related negative emissions would saturate after a number of years and thus their impact on climate is not as certain as avoided emissions from drastically cutting the number of animals produced currently and from stopping deforestation.

Less meat to fight destruction of nature

It would be a disgrace to get to 2050 with a safer climate, but with a planet further depleted of natural life. The effect of livestock on biodiversity loss is so large, that, science tells us, only by shifting towards more plant-based diets we could reduce extinction risks by 20–40% for larger birds and mammals projected to be threatened by extinction by 2060.[3] Many of our most loved animals – elephants, lions, hippos, orangutans, foxes, wolves, bears, even spiders – would have a much better chance of thriving in a world where humans eat less meat and more plants produced in ecological ways.

"Many of our most loved animals – elephants, lions, hippos, orangutans, foxes, wolves, bears, even spiders – would have a much better chance of thriving in a world where humans eat less meat"

3. Tilman, D., et al. 2017. Future threats to biodiversity and pathways to their prevention. Nature, 546: 73–81.

Less meat to preserve water and its quality

Livestock is one of the largest users and polluters of water on our planet. Reducing livestock numbers and meat and dairy consumption will ease a significant pressure on water resources, and will potentially limit the contamination of many water bodies and coastal areas with pollutants from animal farms or feed-crops (for example, chemical fertilisers, pesticides, medical compounds).

Less meat for better health

More natural life, cleaner and less scarce water sources, more food security; all these are benefits of reducing meat and dairy production that will support planetary health, including human health by improving our natural surroundings and the resources we need for survival. In addition, plant-rich diets will greatly improve human health and wellbeing.

Currently the diets consumed by many people are far from healthy. In most regions of the world, the amount of vegetables and fruits in our diets do not reach official recommended levels[4]. A recent study estimates that **5 million deaths could be avoided globally, per year in 2050, by adopting healthier diets with less meat and more vegetables, fruits, legumes and nuts. A larger number of 7 million deaths would be avoided by shifting towards vegetarian diets. The savings of this shift in terms of healthcare and climate damages could reach up to USD 1.5 trillion.[5]**

4. Springmann, M., et al. 2016. Analysis and valuation of the health and climate change cobenefits of dietary change. Proceedings of the National Academy of Sciences, 113: 4146–4151.
5. Springmann, M., et al. 2016. Global and regional health effects of future food production under climate change: a modelling study. The Lancet, 387: 1937–1946.

In short, as we have found from reviewing the scientific evidence on meat and dairy impacts on planetary health, the issue of animal production and consumption is complex and systemic to how we live today. It can not be addressed effectively by isolating its different components, as each component is closely interlinked and interdependent. Reshaping our food system requires an integral approach to societal and policy interventions, that are multi-sectoral and multidisciplinary. We need to look at options for both demand and supply of food, both agriculture and nutrition, both farmers and consumers, as well as for both high- and low-meat consuming countries.

What Greenpeace demands

The food revolution Greenpeace is calling for requires large-scale changes by governments, businesses and individuals. It will need integral changes in the food system from the farm to the home to phase out industrial meat and achieve the halving of production and consumption of meat and dairy by 2050, based on current levels.

Greenpeace is calling on politicians to:

1. End subsidies and policies that support industrial meat and dairy products, and adopt subsidies and policies that promote the production of healthy fruits and vegetables from ecological farms, as well as better meat and dairy from ecological livestock producers[1].

2. Adopt policies to cut public spending on industrial meat and dairy products while increasing economic support towards plant-rich options sourced from local ecological farmers, and replace remaining meat and dairy by goods produced by ecological farmers. In particular, urge public authorities to quickly adopt procurement policies for public canteens that support this model.

3. Adopt policies driving change in dietary habits and consumption patterns, including setting targets towards less meat and dairy.

4. Involve decision-makers from the health and environmental sectors in the design of agricultural policies, due to the wider impacts of the livestock sector on human health and the environment.

Greenpeace is also calling on **business and corporations** to put planetary health over profit and publicly commit to a transition towards plant-based diets and ecological meat and dairy, by establishing a roadmap to fulfill the needed food-system transformation.

1. Greenpeace's 'ecological livestock' criteria can be found in the Appendix page 40.

Lastly, Greenpeace is calling on all of us, from young people to seniors, to use our collective will and creativity to reimagine the way we eat.

A growing 'less meat' movement

Change can be scary. But a world with less meat is a world with so much more to offer all of us: not just improved personal health and a healthier environment, but something new – the opportunity to reconnect with the planet through our food. By choosing more plant-based foods and less meat, we nourish ourselves and the Earth.

"Every time we take a bite, we have a chance to reaffirm what we care about: our families, our communities, and our environment"

The 'less meat' movement is growing. When we think of the movement to change our relationship to eating animals, two groups typically come to mind: vegans and vegetarians. But today, new players are forming a diverse global movement for a better and more humane way of eating. This broad and rapidly expanding group has labels such as reducetarians, flexitarians, climatarians and part-time vegetarians.

Each action we take counts, from trying a plant-based recipe for the first time, to eating no meat every day, to deciding to eat an ecological meat dish only on weekends, to inviting friends around to enjoy the most delicious plant-based meal they have ever had. There are many exciting culinary ideas around at the moment. Every time we take a bite, we have a chance to reaffirm what we care about: our families, our communities, and our environment. We can create a food system with equity and quality livelihoods for all – for eaters and farmers.

Our environment is at a critical juncture. A diverse global movement is growing in response: demanding a better and more humane way of eating. With innovation in plant-rich food and a new global food consciousness on the horizon, a plant-centric, low-meat and low-dairy diet can become the new normal.

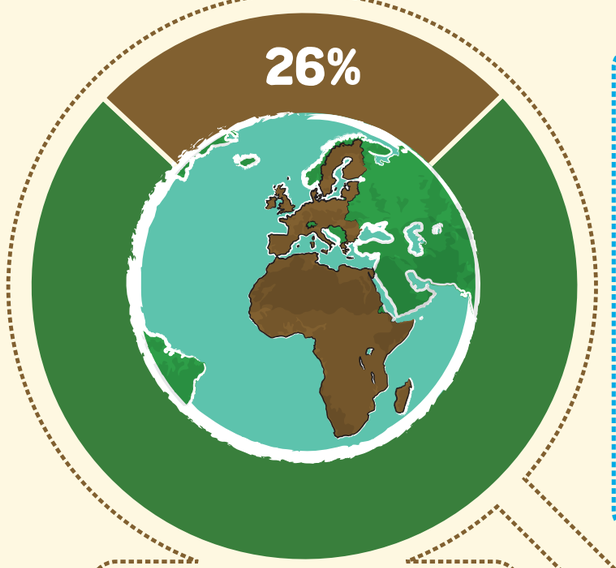
But it all starts with looking into our children's eyes and deciding in our hearts: What future do we want to build for our children today?

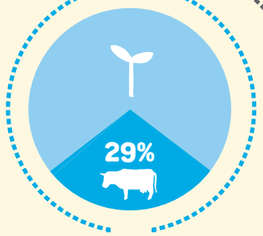
A child eats ecological food at school Escola de Educação Infantil São Pedro in the city of Guabiruba, state of Santa Catarina, Brazil

For every 10 humans currently living on the planet there are approximately:

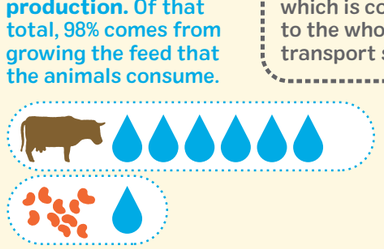
2 heads of cattle, 3 sheep or goats, 1 pig and 30 chickens.

The land required for all livestock production equates to around **26% of the terrestrial surface of the planet** – equivalent to the land area of Africa and the European Union combined.





The total water footprint for animal production accounts for **29% of all agricultural production.** Of that total, 98% comes from growing the feed that the animals consume.



Per gram of protein, the water footprint of beef is six times larger than that of pulses.

Current **greenhouse gas emissions (GHG) from livestock account for 14% of all GHG emissions,** which is comparable to the whole transport sector.

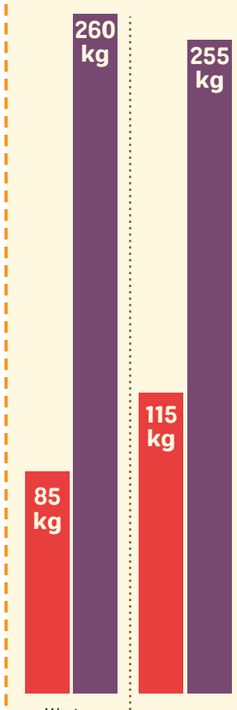
The number of cattle, chickens and pigs slaughtered per capita more than tripled between 1961 and 2009, which amounted to **more than ten animals slaughtered for every person on Earth in 2009.**

If this rate continues to hold, **76 billion animals will be slaughtered to satisfy meat and dairy consumption in 2018.**

Globally, on average, every year each person consumes:

Current global average annual consumption per capita in 2018

The figures are much higher for Western Europe and the USA than for countries in Asia and Africa



Health risks associated with the consumption of red meat in particular include:

Increased risk of developing some cancers, including colorectal, stomach, liver, lung, bladder, pancreatic and oesophageal.

Increased risk of cardiovascular disease and heart attack.

A rise in the global prevalence of obesity and an increased risk of developing type II diabetes.

Greenpeace is calling for a global reduction of 50% in production and consumption of animal products by 2050

GREENPEACE GOAL
(based on expected population in 2050)

50% from 2013 levels to **16 kg** per capita per year

50% from 2013 levels to **33 kg** per capita per year

Expansion of grazing and cultivation of land for livestock feed is often at the expense of **native forest, grassland or savannah.**

In the 50 years from 1960 to 2011, production of animal products was responsible for **65% of global land-use change** and the expansion of cultivated land.

Livestock production in many regions can result in **competition for grazing, water, a greater risk of disease transmission and hybridisation.**

Around 80% of all threatened terrestrial bird and mammal species are threatened by agriculturally driven habitat loss.

Less meat to fight climate change

Less meat to fight deforestation

Less meat to fight destruction of nature

Less meat to preserve water and its quality

Less meat for better health

Appendix:

What Greenpeace means by ‘ecological livestock’

First and foremost, ‘ecological livestock’ means much less meat than is currently consumed globally. Any criteria should always work to enhance this key principle: better meat means large reductions in both production and consumption.

A set of ecological and socially just criteria define ‘ecological livestock’ as the following:

1 Produced with feed not required for human food, and respecting biodiversity and climate:

While human food security is difficult to set limits on, it would include most animals raised on grassland and very little use of feed. A minimum set of general principles include:

- **No feed produced in land linked to deforestation or destruction of intact ecological systems.**
- **Produce feed locally, and as far as possible from waste** (crop residues, food waste, industry waste if safe).
- **Produce feed ecologically, according to the seven Principles of Ecological Farming:**[1] (Supporting food sovereignty, benefiting farmers and rural communities, smarter food production and yields, placing diversity at the center of farming, maintaining sustainable soil health and cleaner water, using ecological pest management, and fostering resilient food systems).
- **What this means specifically per animal sector:**
  - Cows on grasslands and pastures, and feed grown locally.
  - Pigs fed with waste and minimal feed, mostly grown locally.
  - Chicken fed with waste and minimal feed, mostly grown locally.
  - Sheep and goats fed on grasslands and pastures, and feed grown locally (combined with crop residues and waste where appropriate).

1. **Ecological farming:** This method of agriculture ensures healthy farming and healthy food for today and tomorrow, by protecting soil, water and climate. It promotes biodiversity, and does not contaminate the environment with chemical inputs or genetically engineered plant varieties. Ecological farming encompasses a wide range of crop and livestock management systems that seek to increase yields and incomes and maximise the sustainable use of local natural resources whilst minimising the need for external inputs (see Tirado, R. 2015. Ecological farming: the seven principles of a food system that has people at its heart. Greenpeace Research Laboratories Technical Report).

2 Ensuring soil fertility based on manures, compost and the closing of nutrient cycles:

- **Use of soil amendments from crop residues, food waste and manure produced regionally.**[2]
- **Use of legume rotations, compost and organic fertilisers as the principle source of soil fertility.**
- **Substitute chemical fertilisers with organic fertilisers in feed production** (regionally produced).

3 High biodiversity livestock applying to pastures, grasslands, breeds, and feeds:

- **Ensure the preservation of local breeds best adapted to local conditions.**
- **Start to work for the integration of meat, dairy and egg production chains into mixed crop and livestock systems** (e.g. agroforestry).
- **Implement biodiversity measures on production sites** (with list of biodiversity practices).
- **Avoid monoculture production of feed ingredients.**

4 Minimize GHG emissions:

- **Where relevant** (cows, sheep, goats, and in some cases pigs): **implement grassland conservation and practices that increase carbon in the soils (**including limits in the number of animals per hectare, use of cover crops, etc).
- **Feed non-ruminant animals mostly with food waste.**
- **Increase soil carbon by implementing ecological farming practices** (e.g. mulching with crop residues, rotations with legumes, etc).
- **Optimise manure management practices that reduce emissions.**

5 No use of synthetic pesticides or GMOs:

- **Chemical pesticide free.**
- **GMOs free.**

2. The use, recycling or disposal of waste products should always ensure environmental and health safety.

Ecologically fed cows at Sovanry Nhem’s ecological farm in Takeo province, Cambodia

6 Limit the use of antimicrobials to the medical treatment of animals:

- **Reduce use of all classes of medically important antimicrobials in food-producing animals.**
- **Completely restrict use of all classes of medically important antimicrobials in food-producing animals for growth promotion.**
- **Completely restrict use of all classes of medically important antimicrobials in food-producing animals for prevention of infectious diseases that have not yet been clinically diagnosed.**
- **Any new class of antimicrobials or combination developed for human use will be considered critically important unless categorized otherwise by the World Health Organisation (WHO).**
- **Restrict the incorporation of new and upcoming medically important antimicrobials that are not currently used in food production.**
- **Establish surveillance monitoring of antimicrobial agents and antimicrobial resistance in the environment.**
- **Eliminate discharges, losses and emissions of antimicrobial agents to the environment.**

7 Ensure the highest animal welfare standards:

- **No factory farms** (enclosed facilities and individual confinement for animals).
- **No non-curative, non-essential interventions.**
- **Provide a suitable environment.**
- **Prevention of animal cruelty through the whole supply chain.**
- **Proper measurement and documentation of standards.**

8 Ensure human rights along the value chain (farmers, labourers, rural communities, impacted communities):

- **Ensure the rights of Indigenous Peoples are fully respected, including their right to consultation and to give or withhold their free, prior and informed consent.**
- **Production shall not negatively impact, directly or indirectly, indigenous’ rights and resources.**
- **Ensure the rights of contract farmers in adherence with the UN Right to Food.**
- **Ensure fair rural livelihoods and just economic transitions for livestock producers.**

Glossary

Antimicrobial resistance
Antimicrobial resistance occurs when microorganisms such as bacteria, viruses, fungi and parasites change in ways that render the medications used to cure the infections they cause ineffective. When the microorganisms become resistant to most antimicrobials they are often referred to as 'superbugs'. This is a major concern because a resistant infection may kill, can spread to others, and imposes huge costs to individuals and society.[1]

Blue water
This is the water that contributes to surface and groundwater reservoirs.

Biodiversity
This includes all the living things (plants, animals, fungi and microbes) on Earth or in a certain habitat. Biodiversity is often referred to in terms of plant and animal communities that form part of balanced ecosystems. Imbalanced ecosystems can often result in one species becoming more or less abundant, with changes to communities that are often long-term or irreversible.

Business as Usual
The baseline scenario is the Business as Usual (BAU) scenario, which assumes no major changes in trajectory, so that normal circumstances can be expected to continue unchanged.

Carbon cycle
The series of processes by which carbon compounds are interconverted in the environment.

Cardiovascular disease
Stroke, coronary heart disease, aortic disease and peripheral arterial disease are all symptoms of cardiovascular disease.

1. http://www.who.int/features/qa/75/en/

Concentrated animal feeding operations (CAFOs)
These are farms where over 1000 'animal units' are confined for over 45 days per year. The United States Department of Agriculture defines an animal unit as 'an animal equivalent of 1000 pounds (~ 450 kg) live weight, which equates to around 1000 head of beef cattle, 700 dairy cows, 2500 pigs weighing more than 250 kg, 125,000 broiler chickens and 82,000 laying hens.

Diabetes
Diabetes is a serious lifelong condition that occurs when the amount of glucose (sugar) in the blood is too high. If left untreated, high blood glucose levels can cause serious health complications. There are two main types of diabetes: Type I and Type II.

Deforestation emissions
Deforestation results in carbon that has been stored in the plant material (leaves, wood, roots) and soil (microbes) to be released into the atmosphere.

Ecological farming
This method of agriculture ensures healthy farming and healthy food for today and tomorrow, by protecting soil, water and climate. It promotes biodiversity, and does not contaminate the environment with chemical inputs or genetically engineered plant varieties. Ecological farming encompasses a wide range of crop and livestock management systems that seek to increase yields and incomes and maximise the sustainable use of local natural resources whilst minimising the need for external inputs (see Tirado, R. 2015. Ecological farming: the seven principles of a food system that has people at its heart. Greenpeace Research Laboratories Technical Report).

Ecological livestock
This method of livestock production integrates farm animals as essential elements in the agriculture system; they help optimise the use and cycling of nutrients and, in many regions, provide necessary farm working force. Ecological livestock relies on grasslands, pasture and residues for feed, minimising use of arable land and competition with land for direct human food production, and protecting natural ecosystems within a globally equitable food system (see Tirado, R. & Kruszewska, I. 2012. Ecological Livestock: Options for reducing livestock production and consumption to fit within ecological limits, with a focus on Europe Greenpeace Research Laboratories Technical Report).

Eutrophication
This is the over-enrichment of nutrients in aquatic (freshwater and marine) systems that can cause algal blooms and low oxygen levels.

Gene-editing
The use of biotechnological techniques to make changes to specific DNA sequences in the genome of a living organism.

Global land-use change
Globally, land is used for a number of human activities and change in land-use, such as when natural habitats are altered, is a major driver of environmental change at local, regional, and global scales, with important impacts on biogeochemical cycling, ecosystem structure and function, and greenhouse gas emissions.

Green water
This is gathered from rainwater.

Grey water
This is the volume of water that is required to dilute, or assimilate, a pollutant.

Holistic
A systemic approach in which the parts of something are considered to be intimately interconnected and explicable only by reference to the whole. Ecological problems usually require holistic solutions.

Industrial agriculture
This is a way of growing food that includes the intensive use of external inputs, such as fertilisers, pesticides and antibiotics. Industrial agriculture is generally focused on maximising yields, often at intensive scales.

Livestock
Livestock are domesticated animals raised in an agricultural setting to produce commodities such as meat, eggs, milk, fur, leather, and wool, and often also to carry out work.

Nitrogen cycle
The continuous processes that result in atmospheric nitrogen and nitrogenous compounds in the soil being converted, by nitrification and nitrogen fixation, into substances that can be used by green plants. The substances are then returned to the air and soil as a result of the decay of plants and denitrification.

Phosphorus cycle
This is the biogeochemical cycle that describes the movement of phosphorus through rocks and soils, water and living things on Earth. Unlike many other biogeochemical cycles, the atmosphere does not play a significant role in the movement of phosphorus.

Planetary boundaries
These boundaries describe the systems that are vital for human existence on Earth and aim to quantify the current position in 'operating space' within them – from healthy to beyond the safe limits. Nine planetary boundaries have been described so far: 1) land system change, 2) biosphere integrity or biodiversity loss, 3) biogeochemical flow (nitrogen and phosphorus pollution), 4) climate change, 5) freshwater use, 6) novel entities, 7) ocean acidification, 8) stratospheric ozone depletion and 9) atmospheric aerosol loading.

Plant-based/plant-rich diet
This is a diet that is based primarily on vegetables, pulses, fruits and nuts. It might also include small amounts of animal products, such as dairy, eggs and meat products very sparingly. Greenpeace recommendation is for no more than 300 g of meat products per week, and 600 g of milk per week (to be achieved globally by 2050). These foods can be grown using the ecological agriculture principles promoted by Greenpeace. The plant-based diet is also referred to as plant-rich diet.

Vegetarian diet
Usually referred to as the lacto-ovo vegetarian diet, which is a plant-based diet with a moderate intake of eggs and dairy products. It is the most common form of plant-based diet and fulfils all nutritional requirements. The lacto-ovo vegetarian diet, as the plant-based diet, is safe and healthy for pregnant and breastfeeding women, babies, children, teenagers and seniors.

Vegan diet
This is a diet based only on plant foods and with no animal products consumed. This diet is appropriate for people at all stages of life and provides all the necessary nutrients, vitamins, minerals and amino acids apart from vitamin B12 (a B12 supplement might be necessary).

Zoonoses
These are diseases that can be transferred between animals and humans.

The Greenpeace vision of the meat and dairy system towards 2050

GREENPEACE