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Food Research Collaboration

Climate change for food projects:
What it means and what to do about it

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Introduction

Climate change is something we all have to know about, and do something about, urgently. This is especially true for people who work in the food system, because the food system is a huge driver of climate change. Overall, food systems produce around one third of the human-induced greenhouse gas (GHG) emissions that are causing the climate to become dangerously unstable. Climate targets (the national goals that aim to restrict runaway climate change and protect a safe, liveable space for humans and other life forms on our planet) will not be met unless food system GHG emissions are substantially reduced. The decisions we make about food – as eaters, growers, makers, sellers or providers of food for others – have a big influence on whether food-system GHG emissions go up or down. And they need to go down. To limit global warming to 1.5°C (considered the least bad scenario by global climate experts) we need to halve all emissions by 2030.[2]

Abbreviations

CO_2	Carbon dioxide
CO_2eq	Carbon dioxide equivalent (is a term for describing different greenhouse gases in a common unit, therefore the amount of CO2 which would have the equivalent global warming impact).
CH_4	Methane
GHG	Greenhouse gas (any gas in the atmosphere which absorbs heat, and thereby keeps the planet's atmosphere warmer than it otherwise would be).
N_2O	Nitrous oxide

We are using the term 'food project' as shorthand for all the local or community initiatives or businesses that aim to provide food, preferably healthy food, to people who want and need it, favouring food that is produced and distributed in ways that are fair to the growers, workers, providers and eaters. These food projects may be growing schemes, co-ops, food banks, sustainable food hubs, cafes, box schemes or other initiatives, and they may be charities, businesses or social enterprises.

'To change everything, we need everyone. Each and every one of us must participate in the climate resistance movement. We cannot just say we care; we must show it'

- Greta Thunberg, Climate Activist[1]

It's true that the industrial food system causes the lion's share of negative impacts. Many food projects may feel they are not to blame – indeed, the reason many food projects exist is to be more sustainable (that is, have fewer negative impacts on the environment and society) than Big Food.

But not being to blame doesn't mean not having to take action. Food projects need to adapt to the effects climate change will have on our diets because many of the impacts are now inevitable. And food projects also need to review how they operate in order to ensure they are doing as much as possible to reduce future negative impacts.

Many people working in local or community food projects already know this – but they may also have other priorities, especially in times of rising costs and prices, and individual hardship. They may be focused on the basic, essential service of making sure people have enough food for themselves and their dependents – by running a food bank or providing meals to vulnerable people. They may be flat out trying to make a living by growing or selling healthy food. Or they may be trying to ensure that the farmers and growers who produce food get paid a fair price. All this work is vital – but it is no longer enough. Everyone working in the local and community food sector must now take into account the climate impacts of the foods and the services they provide.

That said, it can be hard, especially when the main focus of your work is something different, to find clear, reliable information. It is difficult to know what to do that makes a difference. And it is challenging to explain the reasons for changes -- to employees, customers, clients, volunteers or funders.

This report, written by a team of climate and food system scientists[i], aims to fill that gap. It is intended to help local and community food projects and all the people who work in and campaign for them to understand how the decisions they make affect the climate, and what practical changes they can make to protect us all and future generations.

i. See 'About the authors' on the back cover.

Climate change: the basics

'Greenhouse gases' are the gases that are causing the climate to change: to become hotter, wetter, stormier and less stable, with consequences that are already being felt and are likely to become increasingly disruptive to human and animal life in the near future. Some greenhouse gases arise naturally, but others are caused by human activity. These are the ones that are increasing at a rate unprecedented in human history. They are called greenhouse gases because they accumulate in the skies above us and form a layer like the glass in a greenhouse, trapping heat close to the planet's surface. This unusual heat is disrupting the climate's patterns – patterns that have been stable for thousands of years.[3] [4]

The increase in the global temperature, by approximately 1ºC between the 1850s and 2000s,[5] has already affected sea levels and coastal geography (through erosion), biodiversity, ice sheets, and the migration and reproduction patterns of species of birds and fish. It has also substantially affected agriculture and water resources.[6] On top of this, with increasing numbers of extreme weather events, rising sea levels and frequent flooding will adversely impact communities living close to coastal areas; and livelihoods dependent on coastal agriculture or fisheries may be at risk.[7]

Climate change is an endless cycle, with 'feedback loops' that could potentially become uncontrolled. For example, permafrost (ground that has in the past been permanently frozen) is melting due to warming, which releases methane (a greenhouse gas), which in turn causes more warming. So to some extent climate change is unpredictable. However, models of climate change suggest that by taking action now to reduce GHG emissions, the most serious consequences can be avoided.

Global warming is unequivocal. Most of the warming comes from greenhouse gases and many of the changes being observed are unprecedented.[8] Carbon dioxide (CO_2) is responsible for more than a half of global warming, followed by methane (CH_4) and nitrous oxide (N_2O). Although natural events, such as volcanoes or changes in solar radiation, can have a big effect when they occur, this represents a very small impact over time. Almost all the warming over the last 200 years has been caused by human activities.[9] The increase in GHG emissions and global temperature are directly connected, meaning that if we double the amount of GHG emissions we double the amount of global warming.[10] [11]

It is important to note that while everyone will be affected to some extent, those experiencing poverty are likely to be most affected.

Climate change and food

The ways in which we produce and consume food cause up to one-third of all human-caused greenhouse gas emissions.

The main causes are as follows:

- When forests are cleared to make way for agriculture; the amount of carbon that is stored (or 'sequestered') in soil and vegetation is reduced.
- Methane is produced by the 'burping' of some grass-eating animals (caused by their digestive processes), and from manure, rice cultivation and food waste.

Know your greenhouse gases

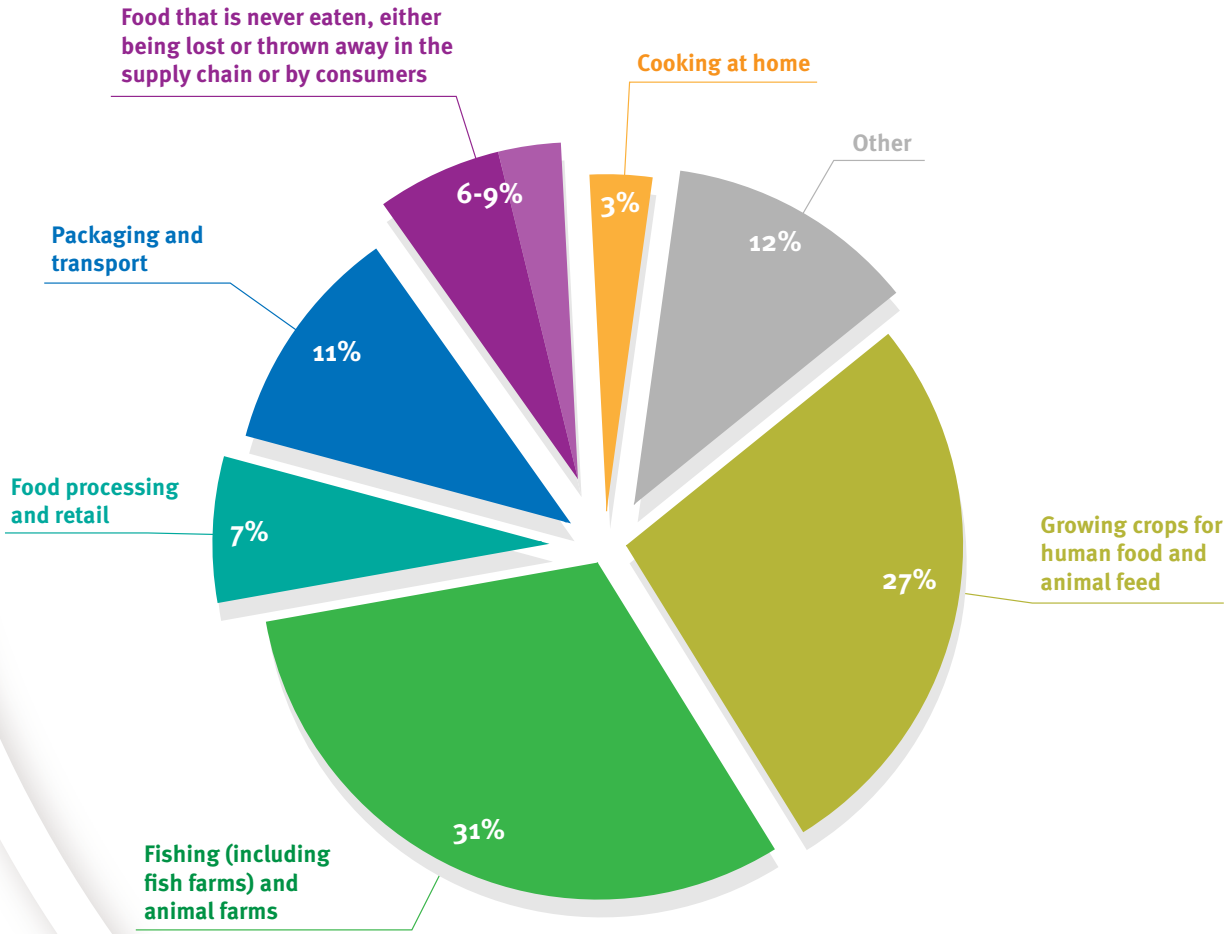
Among food system GHG emissions, carbon dioxide is the largest contributor, responsible for nearly 60%,[12] with the carbon dioxide coming from land-use change (such as from forest to cropland), from the energy used for different activities in the food system (such as processing or transport), and from the production of 'inputs' (such as fertilisers, which use a lot of gas). Methane emissions add approximately 24%, mainly from livestock raising, rice cultivation (paddy rice) and food waste management (when food waste is sent to landfill rather than composting, it produces methane because of the lack of air in the tips). Nitrous oxide, mainly from fertiliser, contributes around 16%, making the food system the major source of this gas globally.[13]

Each greenhouse gas has a different effect on warming the Earth (known as its 'warming potential'). Consequently, it is not just the amount of each gas but also its warming potential that determines its contribution to the climate crisis. In technical terms, the warming potential is a way to measure the ability of the gas to absorb energy and the time the gas lasts in the atmosphere. The common time frame used is 100 years.[14] Carbon dioxide, which has the lowest warming potential in a 100-year time frame, is the largest cause of warming. Other gases' contributions to global warming are expressed in terms of their 'equivalence' to carbon dioxide (CO_2eq)[15]. Methane has 28-36 times more potential to warm the Earth than carbon dioxide, while nitrous oxide is nearly 300 times (265–298) more potent than carbon dioxide.

- When fertiliser is applied to crops, nitrous oxide is emitted.[16] [17]

More than a quarter of the food system's GHG emissions are linked to **land use**, including using land to raise livestock and grow crops for human consumption. The rest are linked to agricultural and food **supply chain activities** such as processing, manufacturing, distribution (through shops and restaurants), and **waste disposal**.[18] The relative contribution of these activities changes depending on the country, but there is a consensus that developed countries have a larger contribution from supply chain activities such as food transport (these emissions have nearly tripled since 1990) and food waste disposal.[19]

Figure 1: Percentages of global food system GHG emissions



Growing crops for human food and animal feed produces around 27% of global food systems GHG emissions, while fishing (including fish farms) and animal farms emit 31%. Food processing and retail account for 7%, while packaging and transport account for 11%.[20] Emissions from food that is never eaten, either being lost or thrown away in the supply chain or thrown away by consumers, accounts for 6-9% of global food system GHG emissions.[21] [22] Cooking at home accounts for approximately 3%.[23]

The world's growing population, as well as a global shift towards dietary patterns that give rise to higher emissions (as people globally eat more meat and dairy, for example), means that on current patterns food is expected to produce 80% *more* GHG emissions in 2050 compared to today.[24]

Most of the global initiatives to reduce GHG emissions involve 'decarbonizing' energy and transport systems by decreasing their reliance on fossil fuels (which emit a lot of carbon) and promoting the use of renewable sources. However, most food-related emissions do not come from fossil fuels. This means that the more the energy and transport sectors switch to clean energy and reduce their share of GHG emissions, the bigger the share food emissions take up in total emissions. So food-related emissions will become even more important in the quest to overall reduce GHG emissions.[25]

So – the food system affects climate change. And conversely, climate change affects food – both availability and prices. The types of farming that can be practised in different regions will change as temperature and rainfall change, with effects on both local food

supplies and long-distance supply chains. Some regions (Canada, for instance) may be able to produce more food due to a rise in temperature, while most continental and equatorial regions (such as South America and India) will see a decrease in production under projected climate change.[26] [27] For example, the Institute for Agricultural Research in Morocco describe as potential changes in the region: a reduction in the growth period of regional crops and an increase in the risk of dry periods affecting crops.[28] Crop 'yields' (the amount of food produced by a crop) will be affected by alterations in the number and spread of pollinators, such as bees, which are involved in the production of edible grains and fruits. Southern Europe, where the UK sources counter seasonal produce, will face yield declines, especially for summer crops such as maize, sugar beet and sunflower.[29] Global fish populations are expected to decrease, which will have an impact both on populations dependent on fishing for their livelihoods, and on people whose diets rely on fish. Climate change will be responsible for worsening the spread of diseases, pests and toxins, which will affect the amount of food produced on farms (including fish farms).[30] [31] These physical disruptions to food supplies, and the price increases they cause, also have knock-on effects on trade. Such disruption has in the past been linked to civil unrest.[32]

In summary, climate change is relevant to food systems in three ways. First, the ways in which we currently produce foods and the diets we try to maintain, especially in the developed world, have made a big contribution to the processes that are destabilising the climate. Second, climate change will increasingly affect the foods that are available to us and their prices. Third, by changing how we grow food and changing our diets, we can help to avert the worst impacts of climate change.

One-fifth of food system GHG emissions are due to energy use

The food system is a large user of energy, because energy is required for many food system activities – to produce fertilisers, drive farm machinery and heat glasshouses, as well as for supply-chain activities (such as meat processing, milling, baking, refrigeration, freezing, and transportation), and for commercial and domestic storage and cooking. As a result, approximately one-fifth of food system GHG emissions come from food system energy use.[33] This means that swapping to clean sources of energy in the food system can help reduce climate impacts. In the UK, refrigeration is responsible for 30-60% of the energy consumed by the retail and supermarket sector[34] (this sector's emissions from energy have grown more than fourfold since 1990). Globally, packaging accounts for around 5% of energy use, which is more than transportation (4.8%).[35]

Fertilisers are essential – but they also drive climate change

The **fertilisers** used to produce a food make a substantial contribution to that food's climate impacts – as a result both of emissions from the fertilisers themselves, and (in the case of synthetic fertilisers) from the manufacturing process. For example, fertilisers cause about one-third of the total emissions for dried coffee.[36] For bread, the GHG emissions due to fertiliser use are roughly equal to the weight of the bread.[37] [38] But fertilisers provide crops with essential nutrients, such as nitrogen, and this increases the amount of food they produce. They are essential to produce enough food for the world's population.

Manure (animal faeces and urine) and compost (decomposed plant material) are examples of natural fertilisers. They benefit the soil, but in the case of manure they also give off GHG emissions. The quantity of nitrogen-like molecules contained in natural fertilisers is relatively low, so large volumes may have to be added to the soil.[39] As a result, manure deposited on grasslands and pastures is the second largest source of GHG emissions on a dairy farm. In fact manure is responsible for 7% of both agricultural methane and nitrous oxide emissions.[40]

Synthetic fertilisers are produced by heating nitrogen gas (taken from the atmosphere) to very high temperatures and then compressing it with high pressure. This takes a huge amount of energy,[41] [42] and consequently accounts for a substantial amount of GHG emissions. In the European Union, synthetic fertilisers are responsible for about 14% of food system GHG emissions.[43] [44] [45]

How climate impacts vary between foods

Different foods have very different climate impacts. For example, broadly speaking steak causes more than 10 times the emissions of beans. But even for a single type of food there is a large range in climate impact, depending on how that food is produced, transported and prepared. Thus beef from cows reared on freshly deforested land can be responsible for 20 times the emissions of beef from an efficient dairy herd; and air-freighted asparagus causes six times more emissions than its local, seasonal counterpart.[46]

We've already seen that having to refrigerate foods, along the supply chain as well as at home, adds to the GHG emissions of those foods. So does the quantity and type of packaging used. But both refrigeration and packaging can help prevent waste – and wasted food means that all the emissions that arose from producing it were, in effect, pointless and could have been avoided. That's why avoiding food waste is a good way to reduce dietary GHG emissions. Transporting foods also changes their impacts, depending on the mode of transport (boat, plane or truck) and the distance travelled (local, overseas). Perishable fruits like strawberries mostly come to the UK by plane when they are not in season in the UK.[47] A plane from Morocco might fly 2400 km to the UK, causing 280g CO_2eq for an 80g portion.[48] Alternatively, a lorry might travel approximately 400 km across the UK, causing 4g CO_2eq for the 80g portion of strawberries.[49]

All this means that **the decisions we make about foods have great potential to reduce emissions**. The foods we choose, how they were produced and transported, how we prepare them and how much or how little we waste: all these factors have an impact. At the same time, some issues of widespread concern among the public, such as 'food miles' (from transportation) and packaging, often have a much lower climate impact than the types of food themselves.

Looking at three versions of an evening meal shows how emissions can vary. Again, the emissions are measured in grammes or kilogrammes of carbon dioxide equivalent (g CO_2eq or kg CO_2eq).

1. A lower-emissions dinner which includes a chickpea tikka masala with bread, tap water, and chocolate mousse made from aquafaba (the water from cooking chickpeas) comes in at 847g CO_2eq.
2. A moderate-emissions dinner which includes a chicken version of the chickpea tikka masala, rice instead of bread, a beer, and apple pie with cream for dessert, comes to over 3kg CO_2eq, with approximately 1kg of emissions from the chicken.
3. A higher-emissions dinner which includes a portion of fried steak and fries, green beans brought to the UK by air, a glass of wine, and chocolate mousse with cream and air-freighted raspberries, comes to approximately 13kg CO_2eq, with beef steak the biggest contributor.

Comparing the three meals, **the higher-emissions meal is 13 times worse for climate change than the lower-emissions one.**

Experts agree that to limit global warming to 1.5°C we need to halve all emissions by 2030. The global average food-related emissions per person per day are 6kg CO_2eq. The UK average is slightly higher, just over 6kg CO_2eq per person per day. Halving this means reducing dietary emissions to a daily average of 3kg CO_2eq per person. Of the meals above, the first is well inside the limit. The second exceeds it – and this is just one meal, not a day's food intake. The third meal produces three times as many emissions as the daily target.

The UK average food-related emissions per person per day are just over 6 kg CO_2eq

The key points are that red meat is the highest-emissions food; even the moderate- emissions meal uses up the whole daily budget; and the low- emissions meal, which replaces chicken with a vegan option and makes use of the cooking liquid, thereby reducing food waste, leaves room for more meals during the day.

Studies also reveal that **cooking methods** account for as much as 61% of total emissions associated with specific foods – but adopting different cooking methods can reduce this. For example, microwave-baked potatoes have lower GHG emissions when compared to their oven-baked counterpart.[50] **GHG emissions from home cooking can be reduced by minimizing cooking times and appliance use.** Using an electric pressure cooker is an efficient way of cooking because the cooking time is substantially shortened, and it could reduce emissions.

Some common foods' climate impacts

Meat and foods sourced from animals

It is now widely acknowledged that **meat and foods sourced from animals** have high climate impacts relative to other foods. The biggest contributor to GHG is cattle. So how do cows contribute to climate change? Just like other animals that are raised for human consumption, they have to be fed. The production of large amounts of animal feed requires access to land, which means natural areas such as forests have to be turned into agricultural land. This releases GHG, and so does the use of pesticides and fertilizers to grow these crops and the processing of these crops to prepare them for animal feed.[51] Eating animals generally requires more land and production steps and thereby impacts the natural world more, and uses more energy, than eating plants directly.[52] Different from other animals though, cattle release an equally large amount of GHG also through the ways in which they eat. In fact, 5% of all calories eaten by cows are burped out as methane,[53] a potent GHG. Cows differ from most other animals in that they have four compartments in their stomachs to help them digest grass. The biggest is called the rumen (which is why cows are called ruminant animals, like sheep, goats and deer). The rumen is where microbes produce methane through a digestive process called 'enteric fermentation'.

The overall GHG emissions from **milk** are double the milk's own weight,[54] considering emissions from burping, the amount of milk produced per day (if the cows produce less milk each day, then the emissions will be higher per litre) and the impact from cow poo (manure produces methane and nitrous oxide, adding about 50% to the total milk emissions).[55] [56] But it's worth noting that this number can vary by more than 50% depending on factors such as how the dairy cows are raised (e.g., in fields or in buildings) and what they are eat.[57] The packaging of the milk causes less than one-twentieth of the GHG emissions, compared with the milk itself.[58]

Yogurt, which consists of milk thickened by bacteria, has lower GHG emissions than cheese, cream and butter, and similar emissions to milk (i.e., twice its own weight.[59])

It takes roughly 10kg of milk to make 1kg of **cheese**. Consequently 1g of cheese produces 16g of CO_2eq emissions or 16 times its own weight.[60] We can reduce emissions from cheese by simply reducing the quantity we eat or by replacing it with low-impact alternatives, such as plant-based cheese (1.4g emissions per gramme) – but these frequently lack nutrition.[61] [62] [63]

'...one 225g steak causes the equivalent GHG emissions to taking a transatlantic flight every year or driving a fossil-fuelled car about 70 kilometres.'

Beef is the biggest carbon culprit among meats. Adding up how many days a cow lives before being slaughtered and how much this cow eats per day shows that the total emissions for beef are around 46 times the portion weight.[64] So one 225g steak causes the equivalent GHG emissions to taking a transatlantic flight every year or driving a fossil-fuelled car about 70 kilometres (43.5 miles). Again, however, the total emissions vary depending on how the beef is produced. For example, feeding cows a rich diet, such as soy, which requires more land to grow and can cause deforestation, or clearing land to create grassland to feed cows, can increase beef's total GHG emissions.[65]

Table 1. Examples of carbon emissions per food portion

Food	CO_2eq / 250g portion
Rice	640g
Dairy Milk	550g
Dairy Yogurt	500g
Cheese	3975g (~4kg)
Beef	11808g (~12kg)

Plants and plant-based foods

Plants and plant-based foods have an important role helping alleviate climate change. Legumes (a type of plant that includes beans, peas and lentils) have bacteria in their roots which take nitrogen from the air and convert it into a molecule that the plant can use, thus reducing the amount of nitrogen-based fertiliser needed. This means that beans, for example, have relatively low GHG emissions, but compared to other vegetables (such as

potatoes) have higher nutritional value, including fibre, calories and protein. But once again, it's about more than just the food item. Comparing the GHG emissions of dried v. canned beans and different cooking methods, canned beans reheated in a microwave, taking into account the steel packaging and the canning process (using fossil fuels),[66] cause twice their own weight in emissions, whereas beans cooked using a pressure cooker cause approximately their own weight in GHG emissions.

Rice, while lacking in nutrient density compared to other grains, such as oats, millet and barley, is mostly grown in flooded fields, which requires far more labour and environmental resources, such as water, than dryland crops like wheat.[67] Rice is grown in water primarily to stave off pests and to keep weeds away from the rice paddies. As the remains of living things die off and decompose in the water, nitrogen compounds are released, feeding the rice, and microorganisms produce a large amount of either carbon dioxide or methane, which is released from submerged soils to the atmosphere.[68] [69] Estimates have suggested that approximately 2% of human-caused climate warming, and 10% of all methane emissions, can be attributed to rice farming.[70] This means that a portion of 200g of cooked rice causes double its weight in emissions.[71] Considering the importance of rice as a staple crop for much of the world (it provides more calories to the global population than any other food), researchers have worked to adapt production practices to make its cultivation more sustainable, such as reducing water consumption by keeping the field flooded for shorter periods of time,[72] and reducing overall emissions by developing new varieties of rice with higher yields.[73]

For many more details on how different foods contribute to climate change, and how to calculate the impacts of foods and diets, we recommend *Food and climate change without the hot air* by Sarah Bridle[74] and the website Take a Bite out of Climate Change.

What you can do

The issues described here present big challenges. All sorts of interconnected things need to change: the way we farm, trade, shop, plan meals for ourselves and each other, cook, and dispose of leftovers and waste. Changes are needed in the laws and regulations that underpin the whole food system. You may think that it is up to governments to make the necessary changes, or that the huge corporations doing most of the climate damage should take most of the responsibility. Both these statements are valid.

But as the climate campaigner Greta Thunberg says in the Tweet quoted at the start of this report, to change everything we need everyone.

First, the big, systemic changes will not be possible without our political and practical support. What we all do can prompt change on the part of governments and corporations.

Next, multiple actions with a small climate impact add up to a big climate impact.

And finally, precisely because climate change itself will affect us all – and the poorest and most vulnerable first and worst – everyone needs to know what is happening and how they can take meaningful action in their own lives. Climate action is not something that should be done 'by' some people 'to' other people.

To meet climate goals – and thereby ensure a safe living space for ourselves and future generations:

- food system GHG emissions must fall
- while food systems continue to provide enough nutritious food for a growing population
- with minimal negative impacts on other life-supporting resources such as water, air quality and biodiversity.[57]

In all of this, equity is paramount. Steps to reduce food's climate impacts should not fall hardest on people who are already living with food poverty, food anxiety or diet-related ill health.

As this report has shown, whether you are deciding what foods to grow, cook, sell or provide for customers or clients, the decisions you make are relevant to climate change and can help reduce the food system's impacts. The following suggestions are just a start, to help you begin the journey.

1. Think of the climate as well as cost and nourishment

Food projects already juggle prices paid and charged, and may consider the healthiness of the food being offered. The urgent need now is to include climate in the mix. Substitute lower-emission foods for higher ones here and there, where there isn't a cost penalty (some lower-impact choices will be cheaper) or where a higher cost can be balanced out over time. For example, use seasonal fruit and vegetables in preference to (imported) out-of-season ones, trial a 'meat-free' day or promote plant-based alternatives to meat.

2. Do a mini audit of climate performance

Make a list of the activities your organisation performs and consider whether any of them could change to reduce impacts. Could you sometimes change your cooking methods to reduce fuel use? Does your electricity come from a renewable supplier? Could you pack food differently, or transport it in different ways?

3. Avoid food-related waste

Food waste represents a waste of all the energy and resources that went into its production – and all the emissions generated in that process could have been avoided. In addition, food waste sent to landfill gives off methane. Basic guidelines are: buy what you need, use what you buy, and give away or compost what you can't eat. Incorporate leftovers into new meals, and store things appropriately (fridges should be set at 5º or lower). Find out if your local authority collects food waste for composting, or contribute food waste to a local community garden that makes compost. For packaging waste, recycle everything you can, and for things your local authority doesn't recycle (such as soft plastics), investigate whether local businesses have collection points (many Co-op stores do) or look into the (paid for) recycling services offered by organisations such as First Mile and Terracycle.

4. Learn and teach about food and climate

Boast about your efforts to tackle climate change through food. Tell customers and clients. Share the information in this report with them, so they understand what you are doing and why. Write the need for sustainability into funding applications.

5. Don't get bogged down in the meat v no-meat argument

People have strong feelings, as well as reasons, for their dietary choices. When these are challenged it can be threatening and counterproductive. Changing what we eat to reduce climate impacts does not mean everyone has to be a vegan. Eating *less* meat and dairy is also useful. Getting into polarised arguments about meat and dairy just holds up progress.

6. Campaign for the big, systemic changes

...at the same time as making small, practical changes in what you do. Ask your suppliers for more information about where they source their supplies from. Tell councillors about any problems you encounter – for example with recycling or composting. Get your clients and customers on board: their voices and experience will add force to your arguments.

What the government could do to help you

Some of the steps needed to tackle the food system's climate impacts require action by government. From many possibilities, here are three:

Taxes and subsidies could be used in a targeted way to incentivise low-emissions production and consumption. Taxes on meat are controversial because they are based on the *type* of food and not the *emissions related to it* (for example cheese has higher GHG emissions than chicken, but cheese producers wouldn't be affected while chicken farmers would be[75 76]). One way to avoid this would be to base the tax on the emissions of each food item rather than a food category. This would reward producers for reducing emissions because the cost of their product would decrease, making it more attractive to consumers. This measure would have to be accompanied by support for farmers whose production was affected, to help them transition to more sustainable agriculture. Another option is to reduce the subsidies for high-emission foods (for example, supermarkets often subsidise the price of cows' milk, a relatively high-emissions food, to tempt people into their stores). Removing these subsidies, or transferring them to low-emissions foods, would encourage consumers to make more climate-friendly choices[77].

Mandatory food emissions labelling would make it easier for everyone to see which foods have better or worse climate impacts. If people chose climate-friendly products, this could harness the power of purchasing to drive change. Poorer-performing products would have to improve to hold their market share.

A **climate literacy programme in schools** would educate children about all aspects of climate change – including its vital links with the food system and diet. Among other things, it would help children understand the emissions from different activities (including eating), and thus avoid the main sources of emissions.

References

1. Twitter, 29.11.2019: https://twitter.com/gretathunberg/status/1200374750368976897
2. IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp.
3. Bridle, S. UIT Cambridge Ltd. - Food and Climate Change without the hot air. https://www.uit.co.uk/food-and-climate-change-without-the-hot-air.
4. IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.
5. Rogelj, J., et al., 2018: Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., et al.]. In Press. (2018). https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_Chapter2_Low_Res.pdf.
6. Sixth Assessment Report. AR6 Climate Change 2021: The Physical Science Basis. https://www.ipcc.ch/report/ar6/wg1/. (2021).
7. Hoegh-Guldberg, O., et al, 2018: Impacts of 1.5ºC Global Warming on Natural and Human Systems. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., et al.]. In Press. (2018). https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Chapter3_Low_Res.pdf.
8. Von Stechow T. Zwickel and J. C. Minx et al. IPCC, 2014: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. (2014). https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_full.pdf (2014).
9. IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp. (Intergovernmental Panel on Climate Change, 2014). https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_AR5_FINAL_full_wcover.pdf
10. Intergovernmental Panel on Climate Change. Anthropogenic and Natural Radiative Forcing. in Climate Change 2013 – The Physical Science Basis: Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change 659–740 (Cambridge University Press, 2014). doi:10.1017/CBO9781107415324.018.
11. IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., et al)]. In Press. (2018). SR15_SPM_version_report_LR.pdf.
12. Oenema, O. et al. Reducing nitrous oxide emissions from the global food system. Current Opinion in Environmental Sustainability 9-10, 55–64 (2014).
13. Oenema, O. et al. Reducing nitrous oxide emissions from the global food system. Current Opinion in Environmental Sustainability 9-10, 55–64 (2014).
14. Myhre, G., et al. 2013: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., et al.]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. (2013). https://ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf
15. EPA, U. S. & OAR. Understanding Global Warming Potentials. U.S. Environmental Protection Agency (EPA). (2016). https://www.epa.gov/ GHG emissionsmissions/understanding-global-warming-potentials. Accessed on 27/10/2021.
16. Poore, J. & Nemecek, T. Reducing food's environmental impacts through producers and consumers. Science 360, 987–992 (2018).
17. Crippa, M. et al. Food systems are responsible for a third of global anthropogenic GHG emissions. Nature Food 2, 198–209 (2021).
18. Crippa, M. et al. Food systems are responsible for a third of global anthropogenic GHG emissions. Nature Food 2, 198–209 (2021).
19. Tubiello, F. N. et al. Greenhouse gas emissions from food systems: building the evidence base. Environ. Res. Lett. 16, 065007 (2021).
20. Poore, J. & Nemecek, T. Reducing food's environmental impacts through producers and consumers. Science 360, 987–992 (2018).
21. Poore, J. & Nemecek, T. Reducing food's environmental impacts through producers and consumers. Science 360, 987–992

(2018).
22. Crippa, M. et al. Food systems are responsible for a third of global anthropogenic GHG emissions. Nature Food 2, 198–209 (2021).
23. Frankowska, A. et al. Impacts of home cooking methods and appliances on the GHG emissions of food. Nature Food 1, 787–791 (2020).
24. Springmann, M. et al. Mitigation potential and global health impacts from emissions pricing of food commodities. Nat. Clim. Chang. 7, 69–74 (2016).
25. Bajželj, B., Allwood, J. M. & Cullen, J. M. Designing climate change mitigation plans that add up. Environ. Sci. Technol. 47, 8062–8069 (2013).
26. Schleussner, C.-F. et al. Differential climate impacts for policy-relevant limits to global warming: the case of 1.5 °C and 2 °C. Earth Syst. Dyn. 7, 327–351. (2016).
27. Searchinger, T. et al. Creating a sustainable food future. A menu of solutions to sustainably feed more than 9 billion people by 2050. World resources report 2013-14: interim findings. ISBN: 978-1-56973-817-7. (2014).
28. National Intelligence Council (2009). North Africa: The Impact of Climate Change to 2030 (Selected Countries) A Commissioned Research Report. NIC 2009-007D August 2009. Available online: https://www.dni.gov/files/documents/climate2030_north_africa.pdf
29. J.C. Ciscar et al., Climate impacts in Europe: Final report of the JRC PESETA III project, EUR 29427 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-97218-8, doi:10.2760/93257, JRC112769.
30. Food and Agriculture Organization of the United Nations, United Nations International Children's Emergency Fund, World Health Organization, World Food Programme & International Fund for Agriculture Development. The State of Food Security and Nutrition in the World 2018: Building climate resilience for food security and nutrition. (Food & Agriculture Org., 2018).
31. Hoegh-Guldberg, O., et al, 2018: Impacts of 1.5ºC Global Warming on Natural and Human Systems. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., et al.]. In Press. (2018). https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Chapter3_Low_Res.pdf
32. Bellemare, M.F. (2015), Rising Food Prices, Food Price Volatility, and Social Unrest. American Journal of Agricultural Economics, 97: 1-21. https://doi.org/10.1093/ajae/aau038
33. World in data: https://ourworldindata.org/ emissions-by-sector
34. Tassou, S. A., Ge, Y., Hadawey, A. & Marriott, D. Energy consumption and conservation in food retailing. Appl. Therm. Eng. 31, 147–156 (2011) https://doi.org/10.1016/j.applthermaleng.2010.08.023
35. Crippa, M., Solazzo, E., Guizzardi, D. et al. Food systems are responsible for a third of global anthropogenic GHG emissions. Nature Food (2021).
36. Humbert, S., Loerincik, Y., Rossi, V., Margni, M. & Jolliet, O. Life cycle assessment of spray dried soluble coffee and comparison with alternatives (drip filter and capsule espresso). J. Clean. Prod. 17, 1351–1358 (2009).
37. Goucher, L., Bruce, R., Cameron, D. D., Lenny Koh, S. C. & Horton, P. The environmental impact of fertiliser embodied in a wheat-to-bread supply chain. Nat Plants 3, 17012 (2017).
38. Espinoza-Orias, N., Stichnothe, H. & Azapagic, A. The carbon footprint of bread. Int. J. Life Cycle Assess. 16, 351–365 (2011).
39. Sedlacek, C. J., Giguere, A. T. & Pjevac, P. Is too much fertiliser a problem? Front. Young Minds 8, (2020).
40. Aguirre-Villegas, H. A. & Larson, R. A. Evaluating greenhouse gas emissions from dairy manure management practices using survey data and lifecycle tools. J. Clean. Prod. 143, 169–179 (2017).
41. Stefania, A., Perathoner, S., Quadrelli, A.. Horizons in Sustainable Industrial Chemistry and Catalysis, v.178, ISBN: 9780444641274. eBook ISBN: 9780444641472. Elsevier. p.444. (2019).
42. Erisman, J. W. et al. Nitrogen: Too Much of a Vital Resource. (WWF Nederland, 2015).
43. Bajzelj et al 2013 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3797518/figure/fig2/ . https://ourworldindata.org/environmental-impacts-of-food#the-carbon-footprint-of-eu-diets-where-do-emissions-come-from
44. Sandström, V., Valin, H., Krisztin, T., Havlík, P., Herrero, M., & Kastner, T. (2018). The role of trade in the greenhouse gas footprints of EU diets. Global Food Security, 19, 48-55.
45. https://ourworldindata.org/environmental-impacts-of-food#the-carbon-footprint-of-eu-diets-where-do-emissions-come-from
46. Frankowska, A., Jeswani, H. K. & Azapagic, A. Environmental impacts of vegetables consumption in the UK. Sci. Total Environ. 682, 80–105 (2019).
47. Frankowska, A., Jeswani, H. K. & Azapagic, A. Life cycle environmental impacts of fruits consumption in the UK. J. Environ. Manage. 248, 109111 (2019).
48. Department for Business & Energy & Industrial Strategy. Greenhouse gas reporting: conversion factors 2018. (2018). https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2018. Accessed on 21/10/ 2021.
49. DEFRA 2018. Greenhouse gas reporting: conversion factors 2018. Published 8 June 2018. Last updated18 July 2018. (2018). https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2018. Accessed on 21/10/ 2021.
50. Frankowska, A. et al. Impacts of home cooking methods and appliances on the GHG emissions of food. Nature Food 1, 787–791 (2020).
51. FAO. Global Livestock Environmental Assessment Model (GLEAM) https://www.fao.org/gleam/results/en/ (2022)
52. Hirth, S. Food that matters: sustainability and the material-discursive boundaries of carnist and vegan food practices (Manchester: The University of Manchester) https://www.research.manchester.ac.uk/portal/files/122884960/FULL_TEXT.PDF (2019)
53. Dong, H. et al. 2006 IPCC Guidelines for National Greenhouse Gas Inventories - V4_10_Ch10_Livestock.pdf. (2006).
54. Poore, J. & Nemecek, T. Reducing food's environmental impacts through producers and consumers. Science 360, 987–992 (2018).

55. Dong, H. et al. 2006 IPCC Guidelines for National Greenhouse Gas Inventories - V4_10_Ch10_Livestock.pdf. (2006).
56. O'Brien, D. et al. An appraisal of carbon footprint of milk from commercial grass-based dairy farms in Ireland according to a certified life cycle assessment methodology. Int. J. Life Cycle Assess. 19, 1469–1481 (2014).
57. Poore, J. & Nemecek, T. Reducing food's environmental impacts through producers and consumers. Science 360, 987–992 (2018).
58. Bridle, S. UIT Cambridge Ltd. - Food and Climate Change without the hot air. https://www.uit.co.uk/food-and-climate-change-without-the-hot-air.
59. Frankowska, A. L. Environmental impacts on the food-energy-water nexus in the UK food sector. PhD thesis. University of Manchester. (2019). https://www.research.manchester.ac.uk/portal/files/188963005/FULL_TEXT.PDF.
60. Poore, J. & Nemecek, T. Reducing food's environmental impacts through producers and consumers. Science 360, 987–992 (2018).
61. Poore, J. & Nemecek, T. Reducing food's environmental impacts through producers and consumers. Science 360, 987–992 (2018).
62. Frankowska, A., Jeswani, H. K. & Azapagic, A. Environmental impacts of vegetables consumption in the UK. Sci. Total Environ. 682, 80–105 (2019).
63. Frankowska, A., Jeswani, H. K. & Azapagic, A. Life cycle environmental impacts of fruits consumption in the UK. J. Environ. Manage. 248, 109111 (2019).
64. Poore, J. & Nemecek, T. Reducing food's environmental impacts through producers and consumers. Science 360, 987–992 (2018).
65. Garnett, T. et al. Ruminating on cattle, grazing systems, methane, nitrous oxide, the soil carbon sequestration question – and what it all means for greenhouse gas emissions.
66. Allwood, J. M. & Cullen, J. M. Sustainable Materials: Without the Hot Air. (UIT Cambridge, 2015).
67. Talhelm, T. & English, A. S. Historically rice-farming societies have tighter social norms in China and worldwide. Proc. Natl. Acad. Sci. U. S. A. 117, 19816–19824 (2020).
68. Wassmann, R. et al. Increasing sensitivity of methane emission measurements in rice through deployment of 'closed chambers' at nighttime. PLoS One 13, e0191352 (2018).
69. Redirecting. https://www.google.com/url?q=https://www.researchgate.net/publication/255073144_Methane_emission_from_rice_fields_Wetland_rice_fields_may_make_a_major_contribution_to_global_warming&sa=D&source=docs&ust=1635290379852000&usg=AOvVaw38y-zHWxWWCBpGeQpSqiJF.
70. Bajželj, B., Allwood, J. M. & Cullen, J. M. Designing climate change mitigation plans that add up. Environ. Sci. Technol. 47, 8062–8069 (2013).
71. Bridle, S. UIT Cambridge Ltd. - Food and Climate Change without the hot air. https://www.uit.co.uk/food-and-climate-change-without-the-hot-air.
72. Lasco, R.D. et al. 2006 IPCC Guidelines for National Greenhouse Gas Inventories - Volume 4: Agriculture, Forestry and Other Land Use. (2006).
73. Su, J. et al. Expression of barley SUSIBA2 transcription factor yields high-starch low-methane rice. Nature 523, 602–606 (2015).
74. Bridle, S. UIT Cambridge Ltd. - Food and Climate Change without the hot air. https://www.uit.co.uk/food-and-climate-change-without-the-hot-air
75. Springmann, M. et al. Mitigation potential and global health impacts from emissions pricing of food commodities. Nat. Clim. Chang. 7, 69–74 (2016).
76. Wellesley, L., Happer, C. & Froggatt, A. Chatham House Report. Changing Climate, Changing Diets Pathways to Lower Meat Consumption. (2015). https://www.chathamhouse.org/sites/default/files/publications/research/CHHJ3820%20Diet%20and%20climate%20change%2018.11.15_WEB_NEW.pdf
77. Bridle, S. UIT Cambridge Ltd. - Food and Climate Change without the hot air. https://www.uit.co.uk/food-and-climate-change-without-the-hot-air.

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The writing of this report was led by Dr Alana Kluczkovski who is a biologist running an innovative urban indoor vertical farm with Prof Katherine Denby who is co-leading the FixOurFood Programme at The University of York, together with Prof Bob Doherty. Prof Bob Doherty and Dr Ulrike Ehgartner research alternative food economy initiatives at the School for Business and Society, University of York.

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The team is part of a consortium called Take a Bite out of Climate Change, led by Prof Sarah Bridle , based at the University of York and Dr Christian Reynolds, based at City, University of London, who have been working together since 2018 on research projects to determine the climate change and other environmental impacts of diets, and to develop educational resources to further communicate these outcomes to the public.

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About Us

The Food Research Collaboration is an initiative of the Centre for Food Policy. It facilitates joint working between academics, civil society organisations and others to improve the sustainability of the UK food system, and to make academic knowledge available wherever it may be useful.

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