

# Growing the Good

The Case for Low-Carbon Transition in the Food Sector





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## Executive summary

*The animal agriculture industry is at a cross roads. As this report lays out, a perfect storm is approaching that, one way or another, will bring disruption and change. Transformation of the industry could bring significant benefits in terms of improved public health, better animal welfare and the unique ability to tackle multiple environmental crises simultaneously.*

*Faced with the urgent need to drastically reduce greenhouse gas (GHG) emissions to meet internationally agreed climate targets, our report finds a shocking absence of policies to drive and accelerate low-carbon transition in the food sector. If the transformation is not quick and well managed, the animal agriculture will stumble across various ecological constraints, including water and land availability; worsening climate change will amplify these constraints, harming the productivity and viability of the sector.*

*Crucially, the game-changing innovation in modern computing, biotechnology and food science is now being applied to plant-based and cultured animal products in ways that were previously impossible, leading to an explosion of new products. Improving the price and quality of these products, and the ability to scale them, could lead to dramatic changes. Together with shifting cultural attitudes to the consumption of animal products - especially among the younger generation - this could mark a turning point, disrupting the market just like renewable energy is revolutionising the energy sector.*

*Low-carbon transition in food brings a unique opportunity. Reduction in demand for animal products would be a relatively easy and cheap way to mitigate a significant share of global GHG emissions, especially short-lived but potent methane emissions. It would also liberate vast areas of land, which will need to be maximised as a carbon sink and for nature conservation. This report concludes that governments must step up by putting in place policies to reduce excessive meat and dairy consumption, as part of a general shift towards healthier diets and better food-production systems.*

In the last century, increases in global population, wealth and urbanisation have led to livestock production growing at an unprecedented pace. This has driven unhealthy overconsumption of meat and dairy products, 330 million tonnes (MT) and 812 MT of which are respectively consumed worldwide each year - a rate forecast to grow further, fuelled by emerging economies with growing middle classes.<sup>1</sup> The global population of major livestock species is currently 30 billion<sup>2</sup> - around four times as many animals as humans. The growth in this population has directly caused not only the loss of ecosystems and wildlife but also significant animal suffering, as these animals are increasingly bred in confined spaces and live much (if not all) of their short lives inside giant factory farms.

### ***Climate, environmental and health benefits of low carbon transition***

There are three compelling reasons - the climate, the environment and health - why change *must*, and will, happen soon.

First and foremost, animal agriculture is inextricably linked with the Earth's rapidly changing climate system. It is both a leading source of global GHG emissions and a sector that the impacts of climate change - such as extreme weather events, water shortages and the spread of pests and diseases - will significantly affect. In total, livestock are responsible for around 16.5% of the world's GHG emissions, and are the leading source of methane and nitrous oxide emissions.<sup>3</sup> If expected forecasts for growth in meat and dairy consumption materialise, there will be almost no room within the total allowable global emissions budget for any sectors other than agriculture by 2050.<sup>4</sup>

Increasing this pressure for change is the fact that reducing demand for meat and dairy would be a relatively easy and cheap way to quickly mitigate a significant share of global GHG emissions - especially those from short-lived, but relatively potent, heat-trapping methane. At the same time, this shift in diets could liberate vast areas of land currently supporting livestock production. This land will be needed as both a plant-based food source and, in particular, a carbon sink. As a consequence of these major benefits, modelling studies overwhelmingly suggest that a shift towards healthier diets, lower meat and dairy consumption and significant food-waste reductions is an essential condition to ensure the world's temperature keeps below a 2°C increase, as agreed by the world's governments at the 2015 Paris Climate Conference of the United Nations.<sup>5</sup>

Second, the Earth's environment cannot physically maintain the levels of natural resources required to satisfy current and projected demand for meat and other animal products. Animal agriculture is an extremely resource-intensive way to feed people; today, 70-80% of all agricultural land, including a quarter of all cropland, is required for pasture and the production of feed.<sup>6</sup> This totals one-third of the planet's ice-free land surface. The animal agriculture sector's hunger for land and water makes it the leading source of biodiversity loss through deforestation, pollution, habitat degradation and competition with wildlife for natural resources.<sup>7,8,9</sup> We are currently experiencing what scientists call the sixth great mass extinction in the Earth's history;<sup>10</sup> one of the foremost underlying drivers of this is animal agriculture, estimated to account for about 60% of human-caused biodiversity loss on land.<sup>11</sup> Such is the resource intensity of animal agriculture that it will be impossible to achieve the Sustainable Development Goals (SDGs) across areas related to the environment and food security without a significant reduction in demand for animal products. Reducing demand for such products also brings a unique opportunity to shift production towards more environmentally friendly farming methods, such as free-range and organic production.

Finally, the excessive consumption of animal products in high-income countries is already between two and three times higher than what is considered healthy, and is associated with an increased incidence

of diet-related disease. Mounting scientific evidence is linking our excessive consumption of livestock products, particularly red and processed meat, with increasing incidence of cancer, obesity, diabetes and heart disease. The way animals are produced and killed also increases the risk to humans of novel infectious diseases and is a known driver of antimicrobial resistance (AMR), which has been acknowledged as one of the biggest health threats for humanity in the 21<sup>st</sup> century.<sup>12</sup> Shifting to more sustainable and low-meat diets can bring significant individual and public health benefits where excessive consumption is rife, resulting in massive savings for national health budgets.

### ***The urgent need and opportunity for science-based policy***

The urgent need for change in the animal agriculture sector is compelling on all fronts, and momentum has been building over the past decade. Public awareness campaigns about meat consumption that go beyond traditionally better-known concerns, such as animal welfare, were considered taboo not so long ago but are now gaining ground. Market change is happening very quickly; plant-based products currently represent the highest-growth food category, and are especially popular among the younger generation. This is a challenge for the existing food sector, but a large opportunity for innovative companies that are willing to invest in cleaner and healthier alternative products. Innovation in this sector is also on the rise; a number of disruptive start-ups are offering alternatives to conventional meat and dairy - from plant-based burgers that 'bleed' beetroot juice to animal products grown from cell cultures - that have the potential to be cleaner, and even more affordable, than meat consumed today. Yet, while change is underway, its pace is not in line with the urgency needed to stave off the environmental crises on the horizon.

To think about a low-emissions transition in food systems, this report has examined analogies in the energy and transport sectors, in which contemporary multilevel policies include GHG reduction targets, carbon-pricing strategies and strategies to promote low-carbon alternatives, such as renewable energy, energy efficiency and low-carbon vehicles. The total absence of similar measures aiming to transform the food sector - and, to make this possible, to shift diets - is shocking. Two broad factors are offered to explain this state of affairs: governments' fear of public backlash for seeking to influence consumers' food choices, and the influence of the powerful agricultural and food lobby, which has reacted swiftly and defensively to the smallest sign of shifting public attitudes and political support away from meat and dairy consumption and towards incorporating a range of alternative foods within healthier diets. Compared to other sectors, where low-carbon transition is happening (albeit too slowly), the food sector completely lacks public policies at all levels to drive change towards science-based targets. What's more, most existing policies still support incumbent production systems, providing subsidies and market-support measures to intensive meat and dairy farmers and to the big corporations that benefit from this system. As these players feel threatened by the growth of alternative products, some politicians are even introducing new legislative measures aiming to restrict the market for such products, such as the recent French ban on terms like 'vegan burger'.<sup>13</sup> Through policy inaction, governments are forcing the public to pick up the bill for the environmental externalities of animal agriculture, and denying market opportunities for more sustainable models of food and livestock production.

It does not have to be like this. Research conducted across multiple countries and continents by the influential think tank Chatham House revealed that the public expects governments to take the lead and address such an important issue, and that the risk of a public backlash against ambitious government policies in this area is overestimated.<sup>14</sup> The research also highlighted that, if provided with convenient, tasty and not-too-expensive alternatives, together with sufficient information about the problem, many citizens would be happy to reduce their meat intake.

Governments must now wake up to this and set science-based targets and policies for an orderly transition towards sustainable, low-emission and healthier food systems. They should do this individually (at the nation-state level) and collectively (through intergovernmental institutions, such as the European Union (EU), United Nations Framework Convention on Climate Change (UNFCCC), World Health Organization (WHO), etc.). They should expect resistance to change from the incumbents, but this should not slow down their actions, as the window of opportunity to prevent dangerous climate chaos is closing.

On the positive side, food is the sector where market transformation can happen quickly and have significant short-term benefits, especially through reductions of potent GHGs such as methane. Social norms and practices around food are not set in stone but are constantly changing; just 70 years ago (before the rise of industrial farming), meat consumption was significantly lower. Governments must set clear trajectories for the transition to give certainty to companies and investors; help farmers to adjust to these changes, and create an engaging and desirable vision for citizens of how one of the most important problems of our era can be addressed. The arguments in favour of health, animal welfare and the environment are overwhelming.

# 1. Introduction

*Consumption of animal products has increased steadily since World War II, following the adoption of intensive livestock production methods, a subsequent fall in prices, the rise of fast-food restaurants and supermarkets, and the development of reliable home refrigeration.<sup>15</sup> The United States (US) initiated such consumption patterns and others in the Global North soon followed. Today, people in the Global North consume unhealthy amounts of meat; people in the United States consume six times as much meat as the average African per year.<sup>16</sup> Demand for animal products worldwide is expected to continue to grow, now fuelled by a fast-growing middle class in emerging economies such as China and India. Such high levels of demand and further intensification of production methods are having very significant negative impacts on the environment, human health and animal welfare. These problems have led to civil society, academia, progressive market players and investors calling for reforming our food system – an urgent and essential intervention needed to achieve major Sustainable Development Goals (SDGs) related to halting climate change, biodiversity loss, natural resource depletion and hunger.*

## 1.1. A brief history of meat and dairy production

In prehistoric times, humans hunted and killed wild animals for meat as one of their sources of food. The transition to agriculture around 8000 BC saw humans increasingly farm and live in permanent settlements. Domestication of most common ruminants (cows, buffalo, sheep, goats) and monogastrics (species with one stomach, such as pigs and poultry) known to us today began soon after. People raised

animals to provide food (such as meat, dairy or eggs) and to support crop production (through the provision of draught power and manure). Most animals were fed on locally available resources that were not directly edible for humans, such as pasture for ruminants and household waste and crop by-products for monogastrics.<sup>17</sup>

During the period following World War II, agricultural industrialisation effectively eliminated the need for animals to support crop production, as draught power became increasingly mechanised and synthetic fertilisers were introduced. In the United States (US), within a context of economic growth, rising consumerism and urbanisation, a shift from small family-owned and -operated farms to industrial meat production started to take place. This approach, which sought to maximise livestock production at minimal cost, spread rapidly across the Global North.<sup>18</sup>

Today, the majority of livestock is produced in intensive production systems that are highly unsustainable on environmental and ethical grounds. So-called 'factory farms' rear large animal populations in crowded and unnatural conditions and a highly industrialised manner, dependent on technology and external inputs. While this may be more efficient per unit of food produced, the sheer scale of operations has large overall energy (for heating, air-conditioning and the mechanisation of animal feeding and disposal operations), feed (animal rations are mostly produced off-farm) and drinking water requirements, and makes such farms highly concentrated sources of pollution. Moreover, due to the larger disease burden caused by animals' living conditions, these farming systems also require large volumes of antibiotics to be fed to animals to prevent and treat disease; in many countries antibiotics are also used to accelerate animal growth, making livestock production one of the leading risk factors driving the rise of antimicrobial resistance (AMR) worldwide.<sup>19</sup>

By species, intensive production methods are most common in pork and poultry meat production, with three-quarters falling under such arrangements.<sup>20</sup> Regional variations exist for cattle, although beef production is typically conducted under mixed-farming arrangements (i.e. forage is combined with concentrate feeding),<sup>21</sup> while intensive production methods are more common in dairy production.<sup>22</sup>

Overall, intensive production methods have enabled the meat industry to decrease the costs of both production and animal products - but this has come at the expense of externalising a range of costs onto society as a whole, through the worsening of environmental damage associated with feed production (e.g. water pollution), greenhouse gas (GHG) emissions, human health risks from zoonotic diseases and AMR, poor animal welfare conditions and more.

Meat production continues to increase globally; in 2017 it accounted for 330 million tonnes (MT) worldwide: 120.5 MT of poultry, 118.7 MT of pigmeat, 70.8 MT of beef and other bovine species, and 14.8 MT for sheep and other ovine species.<sup>23</sup> China is both the biggest producer (85.8 MT) and the biggest importer (5.4 MT) of meat and meat products worldwide, consuming a similar amount of meat than that of the US and the European Union (EU) combined.<sup>24</sup> Global milk and milk products production has also increased rapidly; in 2017 it stood at 812 MT, with India (166 MT) and the EU (165 MT) accounting for almost one-sixth of the market each.<sup>25</sup> Delivering the substantial increases forecast until 2050 in meat and dairy production will require both a greater number of animal production systems (or farms) and further intensification of these systems in general, which is likely to worsen the industry's already excessive environmental footprint while further diminishing the welfare of animals used to feed humanity.

The rapid growth in the populations of livestock species has followed growing human demand for animal products. It is now estimated that, at any given time, there are 30 billion livestock worldwide (and 90

billion each year) - four times that of the global human population.<sup>26</sup> By species, the most populous are chickens (22.7 billion), followed by sheep and goats (2.2 billion), cattle (1.5 billion) and pigs (1 billion).<sup>27</sup> This population trend contrasts strongly with those of wild vertebrate animals, which have been decreasing steadily, with an estimated 58% decline since 1970s.<sup>28</sup>

## 1.2. Increasing consumption is the core of the problem

The economic struggles of the early 20<sup>th</sup> century, when the ability to consume meat and other animal products was a symbol of affluence, continue to influence the perceptions of many North Americans and Europeans. Most Western countries rationed meat, dairy, eggs and animal fats during periods of food shortages until the 1950s.<sup>29</sup> However, this changed significantly after World War II; indeed, per-capita meat consumption in the US has risen by 95% since.<sup>30</sup> Such change has been driven largely by a steady drop in prices: ham and steak are respectively 48% and 20% cheaper, and chicken meat prices have fallen by three-quarters while per-capita chicken consumption has increased six-fold.<sup>31</sup>

While it would be wrong to solely attribute higher meat consumption to lower prices, falling prices have certainly been a major driver of consumption changes in Western countries since World War II, and in emerging economies in recent years. This is illustrated clearly by the high price elasticity of demand for meat: a 1% price increase for beef, for example, would reduce consumption by 0.75%, while price elasticity for dairy is (-)0.65, with eggs being the most inelastic at (-)0.27.<sup>32</sup> The weighted elasticity for all animal products is (-)0.65, which means a 10% increase in price (for example, through a meat tax) would result in a 6.5% downward shift in consumption.<sup>33</sup>

Along with a drop in price, increases in income have led to greater purchasing power, and thereby increased spending on animal products to meet cultural preferences (often induced via marketing) for ever-greater levels of meat consumption.<sup>34</sup> As a consequence, meat consumption has steadily risen since the 1960s in the Global North. Today, the average annual meat consumption per capita for OECD countries stands at 86kg, with people in the US consuming 123kg.<sup>35</sup> These consumption levels are two to three times higher than those stipulated in official healthy diet guidelines and have been linked to an increased incidence of diet-related disease, including obesity, heart disease, diabetes and certain types of cancer.<sup>36</sup>

In contrast, meat consumption levels for the average person in Africa and some parts of Asia remain comparatively low, with annual average consumption per capita standing at 14kg and 32kg respectively - below the world's average of 42kg.<sup>37</sup> However, in major emerging economies the amount of meat consumed is quickly rising towards levels seen in higher-income countries, with the average Chinese consumer's consumption currently at around 63kg of meat per year,<sup>38</sup> compared to less than 10kg in 1960.<sup>39</sup> Indeed, growth in poultry and, to a lesser extent, pork consumption in emerging Asian economies is expected to drive future global meat market growth.<sup>40</sup>

Such uneven consumption of animal products is not exclusive to meat. For example, Western Europe's per-capita milk consumption (over 300kg per year) is more than ten times that of certain African and Asian countries (less than 30kg per year).<sup>41</sup> And per-capita egg consumption in Mexico (358 eggs per year) is some six times higher than that in certain African and Asian countries.<sup>42</sup>

# CONSUMPTION OF LIVESTOCK PRODUCTS

Source: OECD-FAO Agricultural Outlook 2017

PER CAPITA



BEEF



PORK



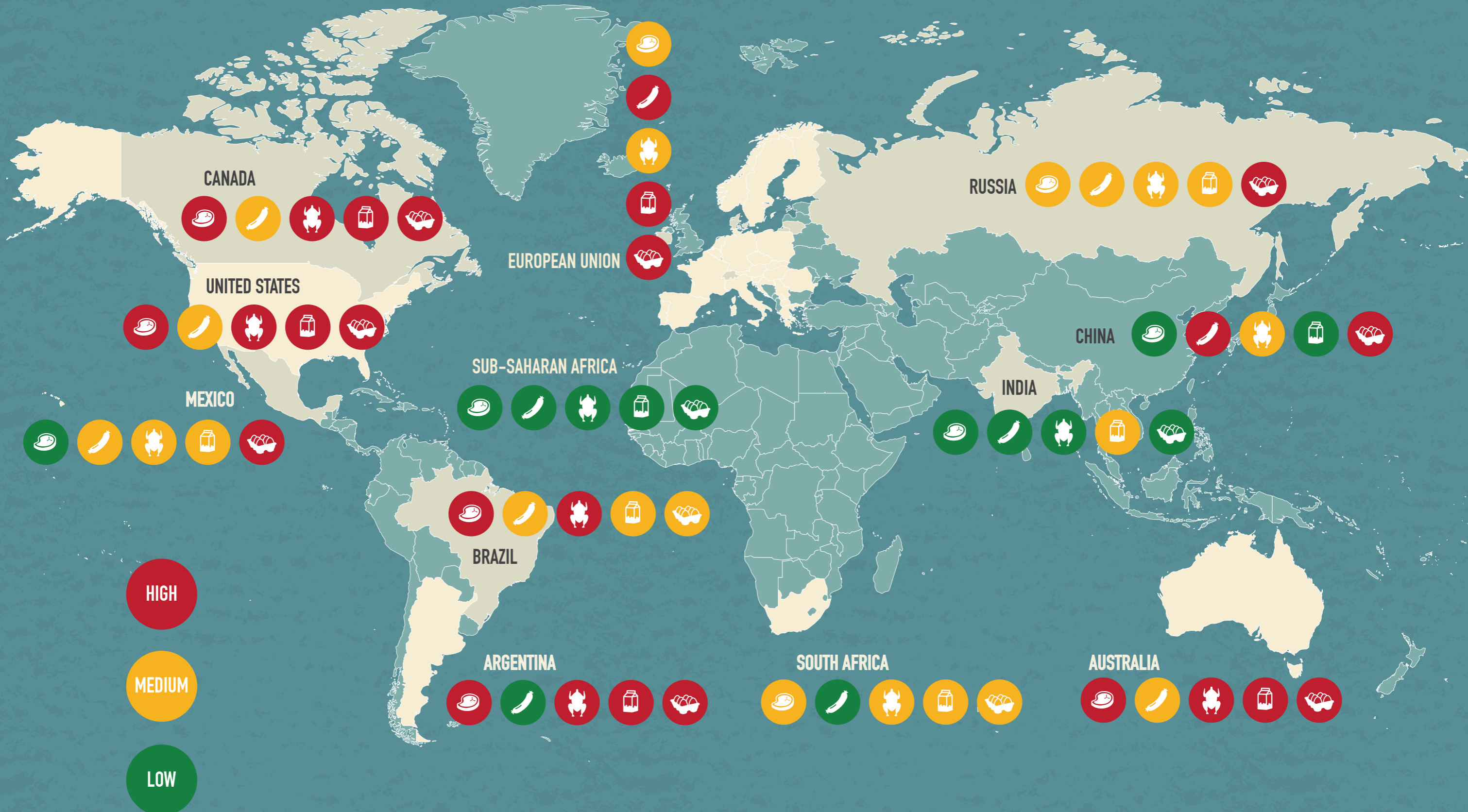
POULTRY



MILK



EGGS



### 1.3. Livestock: a sector at a crossroads

The livestock sector is unquestionably a major global force economically, socially and politically, and is at such a scale that it is a primary driver of global environmental change. Its value is estimated at \$1.4 trillion USD, equal to 40% of agricultural gross domestic product (GDP) worldwide.<sup>43</sup> By comparison, its value represents one-third of that of the fossil fuel sector,<sup>44</sup> but importantly, it supports 1.3 billion people - many of whom are small-scale livestock farmers in the Global South.<sup>45</sup>

What is the future for livestock systems globally? The following chapters provide detailed and extensive evidence that the sector's overwhelming impact on our environment and health - due to its size and production methods - is radically incompatible with addressing humanity's most pressing existential challenges. To put it another way, the reform of the livestock sector is pivotal to achieving many of the SDGs, and is directly relevant to most of them.<sup>46</sup> These include critical issues such as tackling climate change, halting terrestrial and aquatic biodiversity loss, and ending hunger in the context of a growing global population.

Ironically, unrestrained global growth in livestock production and consumption is now driving so much environmental change that it is undermining the sector's long-term viability. Degradation of ecosystems, the impacts of a changing and more variable climate on feed crops and directly on livestock productivity, and changes to patterns of disease and the availability of water and pasture are already being felt. While disproportionate impacts are already suffered by the hundreds of millions of subsistence livestock farmers in the Global South, climate change is also already affecting farmers in the Global North. The 2018 draught has significantly impacted on crop yields around Europe; the German Farmers' Association has called for 1 billion EUR in compensation, with a shortage of cattle feed causing particular concern.<sup>47</sup> Similarly, the Irish government will pay its farmers 4.25 million EUR for fodder imports. This is not new; the European Commission created an exceptional aid for livestock farmers of 500 million EUR in 2015, and the sector continues to receive public money without any commitment to reform.<sup>48</sup>

While climate change will ultimately force the transformation, this will come too slowly. Instead of short-term relief measures, which cost significant amounts of taxpayers' money, governments should consider how to transform industrialised animal agriculture towards a more sustainable and resilient food system. This report shows the way.

## 2. Livestock production and climate change

*'Livestock emissions were all over the menu—in the form of butter, cheese and meat—but they were nowhere to be found on the agenda', reported a Forbes journalist covering the Paris Climate Conference.<sup>49</sup> Indeed, policymakers' discussions have long focused on how to decarbonise the energy, industry and transport sectors but have largely ignored the need for drastic change towards more sustainable agricultural systems. However, the science is now clear that global carbon emissions must fall to zero, meaning it will not be possible to stop climate change without greatly reducing emissions from agriculture, while at the same time using agricultural land to draw carbon dioxide out of the atmosphere through afforestation, reforestation and the use of bioenergy combined with carbon storage technologies. Consequently, the future development of the livestock sector - responsible for the majority of global agricultural emissions and using almost one-third of the world's ice-free land - has the power to either make or break climate targets.*

### 2.1. A major source of greenhouse gas emissions

The livestock sector is a major contributor to climate change; in 2010, it was responsible for a total of 8.1 GtCO<sub>2eq</sub> per annum, or 16.5% of that year's GHG emissions.<sup>50</sup> As a reference point, this is equivalent to the emissions from combustion of all transport fuels.<sup>51</sup> Major GHG emission sources along the livestock production value chain relate to animal-feed production (expansion of grazing and agricultural land, fertiliser production and use for crop production), digestion (methane emissions related to enteric fermentation of grass and ligno-cellulose material by ruminants) and elimination (manure decomposition). Emissions are also associated with slaughtering animals, processing their meat and other products, and the energy and transport used in meat production and distribution.<sup>52</sup>



Cattle are by far the most emissions-intensive type of livestock; typical beef and dairy production are estimated to be responsible for over two-thirds of the sector's emissions. One reason for this is that the process of turning cattle inputs into edible calories and protein is very inefficient; large inputs (animal feed and grass) and large, often problematic outputs (enteric emissions and manure) are required to generate human-edible food.<sup>53</sup>

### Livestock emissions: why do literature estimates differ so much?

Two different types of accounting systems are typically used to calculate total emissions for the global livestock sector. Both are often quoted and reported in the press and elsewhere, leading to some confusion as to what the total emissions figures related to the livestock sector are. The two methodologies are based on either a) *emission source inventory accounting*, or b) *life-cycle assessment*.

#### a) Emission source inventory accounting

This first method is based on discrete categories of direct emission sources (e.g. enteric fermentation) and sinks aggregated together into sectors (i.e. agriculture) under each geographic unit (e.g. nation). This is the form of accounting used by countries to report to the United Nations Framework Convention on Climate Change (UNFCCC) via International Panel for Climate Change (IPCC) guidelines. According to a study by the UN Food and Agriculture Organization (UNFAO), the sum of emissions from enteric fermentation, manure and cropland related to feed would put total livestock emissions at **4-5 GtCO<sub>2eq</sub>**, or **8.8%** of the total in 2010.<sup>54</sup>

#### b) Life-cycle assessment

This second method is based on accounting for the directly and indirect emissions produced along the entire value chain for a particular product or service. It is often used when the goal is to understand where, in a value chain, resource use and environmental impacts occur. According to a revised FAO study, livestock-related emissions along the whole value chain, including direct and indirect emissions, amount to **8.1GtCO<sub>2eq</sub>**, or **16.5%** of the total in 2010.<sup>55</sup> This includes additional sources of emissions at least partially related to the livestock, such as deforestation linked to crop expansion for animal feed.

It is important to understand that, although these two methods may give different numbers for livestock emissions, they are both entirely valid depending on the aim of the analysis. No matter how you measure it, livestock emissions are significant and their reduction is of crucial importance for achieving climate targets.

## 2.2. The future of the livestock sector: current trends at odds with climate goals

With a growing world population and changing diets, consumption of animal products is projected to have increased by 80% in 2050.<sup>56</sup> Emissions associated with the agriculture and land-use change sector could thereby increase significantly by 2050 to 15 GtCO<sub>2eq</sub> or 20 GtCO<sub>2eq</sub>.<sup>57,58</sup> Importantly, this outcome would be incompatible with drastic GHG reductions needed under the objective of the recent Paris Agreement (i.e. keeping a global temperature rise this century well below 2°C above preindustrial levels,

and pursuing efforts to limit the temperature increase even further to 1.5°C) for a number of reasons.<sup>59</sup>

In 2050, annual global emissions must, at minimum, be within a range of 16–31 GtCO<sub>2eq</sub> for the world's temperature to keep below a 2°C increase. Indeed, a greater likelihood of achieving such a goal would require further reductions in emissions to 4–14 GtCO<sub>2eq</sub> during the same period.<sup>60</sup> In that context, if climate change is to be addressed, the forecast increase in demand for animal products and associated emissions by 2050 *alone* would leave very little (or no) room for any other source of human emissions – despite the huge, and potentially very expensive, challenges faced in other sectors to fully decarbonise by this date.

Moreover, even greater efforts will be required in the post-2050 period to stabilise the climate, through near-zero or negative overall emissions across all sectors. This is needed to first reverse current trend in rising global temperatures and then lower them towards a 1.5°C goal. Consequently, there seems to be no emissions space available to allow for current animal-product consumption and production trends to continue.<sup>61</sup> As a result, future investments destined to support unsustainable levels of meat consumption are likely to lead to a food system locked in to high emissions via sunk costs, infrastructure and consumption habits, or else liable to future disruption and stranded assets that are incompatible with future agricultural needs.

### Methane emissions: should they be addressed differently?<sup>62,63</sup>

Different types of GHG can be compared according to their a) *average atmospheric lifetime*, and b) *ability to absorb and trap heat energy in the atmosphere*. These differences are particularly significant when understanding the potential benefits of reducing emissions associated with the livestock sector, the emissions footprint of which differs from other sectors in that much of it is made up of methane and nitrous oxide.

#### a) Average atmospheric lifetime

A GHG's atmospheric lifetime refers to the **amount of time** it takes for a fixed increase in the concentration of a given gas in the atmosphere (e.g. the addition of 1 tonne) to return to natural levels (i.e. the gas is converted to another chemical form or is taken out of the atmosphere via a sink). Of the main GHGs, average lifetimes can vary from about 12 years for methane to 114 years for nitrous oxide and over a century for carbon dioxide. However, because of the Earth's carbon cycle, a portion of carbon dioxide emitted will still exist in the atmosphere for thousands of years after its emissions.

#### b) Ability to absorb and trap heat energy in the atmosphere

This concept refers to the **warming potential** (i.e. amount of heat trapped) of a concentration of a given gas in the atmosphere. The ability to absorb and trap heat energy in the atmosphere differs significantly between gases. To compare different gases, the cumulative amount of heat energy trapped by a given amount of each gas (e.g. a tonne) over a specific period of time is compared (a metric known as the global warming potential (GWP)). By definition, a gas's GWP is always measured relative to that of CO<sub>2</sub>, the GWP of which is equal to 1. Of the main GHGs, the warming effects of fluorinated gases are over 1,000 times higher than carbon dioxide, and the warming effects of nitrous oxide and methane 298 and 34 times higher respectively, when compared over a 100-year timespan.

Due to these differences, climate experts have recently started to call for policies that manage these gases separately.<sup>64</sup> This reasoning does not change the need to drastically reduce *long-lasting* global CO<sub>2</sub>

emissions to zero as soon as possible to stabilise global temperatures, but it does highlight that steeper reduction trajectories for *high-warming* gases would facilitate adaptation to evolving climate change and help achieve the lowest temperature goals (1.5°C). In other words, the opportunity of quickly reducing methane emissions is that, because of its short lifetime in the atmosphere, the impact of its reduction on temperatures could be relatively fast – although only by a fixed amount, relative to the degree to which methane emissions fall. This strategy provides humanity with an additional lever in the climate toolbox that can be used to lower the peak level of warming experienced and to help slow down the rate of warming experienced, helping us to reach the lowest temperature goals (e.g. 1.5 °C) and making climate change adaptation more feasible.

In this context, a reduction in demand for animal products and a reduction in emissions associated with livestock production methods could make a big difference, because this sector roughly contributes about one-third and two-thirds of all man-made methane and nitrous oxide emissions respectively.

### 2.3. Land use: livestock sector reductions are key to allowing other sectors to decarbonise at reasonable cost

Another way in which the livestock sector is pivotal to climate action (and biodiversity conservation) is its unparalleled land footprint. Between 70-80% of all agricultural land is utilised for animal grazing or cropland devoted to producing feed for animals.<sup>65,66</sup> A quarter of cropland, specifically, is used to grow feed for animals; this is projected to increase to 50% by 2050.<sup>67</sup> World Wide Fund for Nature (WWF) estimates that to grow the soy and maize needed to satisfy additional livestock by 2030, agricultural land would have to expand by about 280 million hectares – the land area of Austria, Belgium, the Czech Republic, France, Germany, Italy, Ireland, the Netherlands, Poland, Portugal, Slovakia, Spain and the UK *combined*.<sup>68</sup> This will unavoidably drive further expansion into natural areas, such as forests and grasslands, further increasing livestock GHG emissions.<sup>69</sup> This contrasts strongly with modelling projections that natural land areas will need to play an increasingly important role as carbon sinks to stabilise the Earth's climate, which puts competition for land at the centre of climate policy discussions.

Indeed, almost all GHG reduction scenarios the IPCC has considered to achieve the 2 °C level of ambition require a significant percentage of land to play its role to the full, as a carbon sink is the only feasible way to achieve negative emissions at the required scale post-2050. This would necessarily involve afforestation and reforestation at a huge scale, as well as the provision of significant amounts of biomass to replace fossil fuels in the production of energy, fibre and other materials, such as chemicals, in the power, transport and industrial sectors.<sup>70,71,72</sup> Such a scenario – one that makes achieving climate goals possible – will be near impossible to realise without addressing the amount of land used by the livestock sector.

Of critical political and economic significance is the trade-off between land used for livestock versus land used as an enhanced carbon sink, and the effect this will have on the speed of mitigation required – and so the overall costs of mitigation – in other sectors. This trade-off potentially puts these sectors into direct conflict for emissions space and natural resources, which could risk the feasibility of achieving our climate goals.

Modelling studies show that freeing up land that would otherwise be used by the livestock sector will require both reduction in demand for animal products and increased efficiency – a reduction in land used per unit of product. One study estimates that moving the world by 2050 to the 'Harvard Healthy Diet' – which advocates sparing use of red meat and more moderate consumption of dairy, eggs and poultry

meat – could halve the costs of decarbonising the energy sector up to 2050. It would do so by freeing an area of rangeland equivalent to the US and reducing cropland by the combined land size of the UK, France and Spain. Lower costs to the energy sector would result from a slower decarbonisation pace and the avoidance altogether of the most expensive range of carbon mitigation tools.<sup>73</sup>

### Reducing emissions from the livestock sector: a major gap in climate policy

Despite the significant need to reduce GHG emissions associated with livestock production, the livestock sector's emissions have received little attention from jurisdictions across the world. Indeed, the EU, often seen as the global leader in terms of climate change policy, has taken very little action to drive emissions reductions in this area – a dearth particularly noticeable in its lack of targeting shifts in average meat consumption patterns.

In December 2017, EU institutions reached a political agreement on the framework for realising a 30% GHG reduction in 2030 across the 'non-traded' sectors of the economy (buildings, agriculture, waste management and transport), as well as individual reduction targets member states must achieve.<sup>74</sup> However, the agreement, which NGOs have slammed because of its lack of ambition,<sup>75</sup> is unlikely to drive any reductions in the agricultural sector because it will allow countries with large agricultural sectors to meet the bulk of their overall GHG reduction targets through a number of alternative arrangements, including the use of GHG credits from their forestry sectors and increased efforts in other sectors.<sup>76</sup> Also, current international accounting rules mean that emissions associated with imports of meat, dairy and animal feed from outside the EU continue to be ignored.

To date, the bulk of actions to reduce emissions have been voluntary commitments by the industry.<sup>77</sup> These include emission-reduction targets in the dairy production sector of a non-binding 25% in the US and 20-30% in the UK (both by 2020 and compared to 2009 levels).<sup>78</sup> However, a recent report from the UK's Committee for Climate Change concluded that no significant progress has been made.<sup>79</sup>

### 2.4. Mitigating emissions associated with the livestock sector

Although no substitute to required reductions in production, there are significant mitigation opportunities available to livestock producers to reduce their carbon footprint, based on new technologies and better management of farming systems. Indeed, if producers in any given system, region and agro-ecological zone were to apply the practices of those with the lowest emission intensities, livestock emissions would reduce by one-third while maintaining constant output.<sup>80</sup>

### Is grass-fed livestock better for the climate?

Is all livestock bad for the climate? While cattle are well known to be the most GHG-intensive livestock and source of meat, some argue that, by feeding animals predominantly on pasture and carefully managing how they graze the land, animal welfare can be improved and cattle can, in fact, have benefits for the climate.<sup>81</sup>

This is based on the assertion that, if cattle were grazed properly, their nibbling and trampling actions would stimulate grass growth and soil carbon sequestration to the point that total GHG emissions associated with cattle raising would be balanced by the additional carbon being drawn down into the soil and stored there over time.<sup>82</sup>

To evaluate these claims, the Food Climate Research Network (FCRN) at the University of Oxford recent undertook a comprehensive study. It found that, while it is possible to store more carbon in grassland soil via improved grazing in some contexts, the circumstances where this can happen are narrow, and the amount of carbon that can be drawn down is substantially lower than many claim. In such circumstances, this could only balance emissions at very low stocking densities. And what's more, within decades, soils would return to a new equilibrium and carbon sequestration would rapidly diminish to zero; meanwhile, animals on the land would continue to emit.<sup>83</sup>

Even if the maximum global potential for soil carbon sequestration were achieved through a worldwide change in grazing practices (a very unlikely scenario), this would still only account for 20–60% of emissions associated with solely grass-fed livestock, and then only for a limited time. In addition, any soil carbon sequestration gains could be quickly lost again through a change in land management or climate, making the benefit of better grazing management impermanent and reversible.<sup>84</sup>

The results of the review clearly reinforce the message that, while improved production methods can make a positive contribution (and in ways more diverse than climate change alone), there is no wriggling out of the fact that climate change mitigation requires a very significant reduction in livestock numbers.<sup>85</sup> Were this to be achieved it could, in theory, provide the land and emissions space needed to institute more sustainable farming models.

## 2.5. Curbing demand for meat and dairy is essential

The science is clear: current climate mitigation strategies need to be scaled up significantly to achieve the Paris Agreement's objective. However, in the context of forecast demand growth for meat and dairy of 80% by 2050,<sup>86</sup> even the maximum potential emissions savings from efficiency gains in global livestock production (as described above) would be overwhelmed by this growth, and would therefore not come close to addressing the problem. To reduce emissions from agriculture in real terms between now and 2050, then, immediate demand reduction is essential.<sup>87</sup>

A study exploring the role of food-demand management as part of climate mitigation concluded that - even making optimistic assumptions for future crop yields and 50% food-waste reductions - only a move towards healthy dietary recommendations with fewer animal products would reduce agricultural and land-use emissions below 10GtCO<sub>2eq</sub> (in line with the minimum required reductions) by 2050. A similar conclusion was reached by a study looking at Sweden's climate change commitments and diet.<sup>88</sup>

Avoiding meat and dairy products is the single biggest way to reduce personal environmental impact on the planet, according to a recent comprehensive study led by the University of Oxford.<sup>89</sup> The study found that, in the most extreme case, eliminating meat and dairy consumption would make it possible to feed the world while reducing an area of farmland equivalent to the US, China, the EU and Australia combined. This is because meat and dairy production is a very significant (it uses 83% of farmland), polluting (it produces 60% of agricultural GHGs) and inefficient (it provides just 18% of the calories and 37% of the protein that we eat) use of land.

Similar studies have shown that up to 50% of a person's dietary GHG emissions' footprint can potentially be reduced through reducing or eliminating consumption of animal-based foods.<sup>90,91,92,93</sup> Dietary change has also been cited in a study as the most cost-effective mitigation action available to US households.<sup>94</sup>

A UK study highlighted the climate change benefits resulting from decreasing the amount of meat in the average global diet by everyone switching to a healthy diet, as recommended by the World Health Organization (WHO).<sup>95</sup> This would equate to a maximum of 100g per day (around 36kg per year) of meat per person; the average amount currently consumed by the average UK person is 230g per day. A switch of this magnitude would allow for 15GtCO<sub>2eq</sub> a year to be saved globally by 2050, a large part of which would be achieved through the land freed from food production being used for carbon sequestration activities, such as reforestation or bioenergy cultivation. Similarly, another study conducted by British, Australian and Chilean academics proposed 90g of meat as the maximum consumption average per-capita global target, of which no more than 50g should be red meat, to stabilise emissions from the livestock sector in 2050.<sup>96</sup>

More recently, Greenpeace has estimated the level of meat and dairy consumption compatible with the ecological level the Earth system can sustain while achieving food security, a safe climate and biodiversity. In their analysis, a 50% global reduction of the production and consumption of animal products, and a shift towards sustainable production methods, is needed by 2050. Per capita, this equals an average meat consumption of 16kg (24kg per year in 2030) and 33kg of dairy. Such a decrease would require a substantial reduction of animal products in high- and middle-income countries and constrained growth in demand in low-income countries.<sup>97</sup>

This brings us to an issue of great strategic importance for the way society is likely to respond to the animal agriculture challenge: the question of the comparative economic cost, complexity and speed of different approaches to reducing emissions. In this regard, it seems that dietary change ranks among the simplest, most impactful and potentially cost-effective actions society can take to tackle climate change, while also providing a wide range of further co-benefits for the environment and human health.

### Sustainable consumption: the role of food-waste reductions

What does a sustainable level of consumption of livestock products look like? FCRN believes that the answer includes improvements in the efficiency of livestock production, addressing environmental and welfare impacts of production, increasing the amount of animal parts eaten, reducing waste and adjusting meat consumption accordingly.<sup>98</sup>

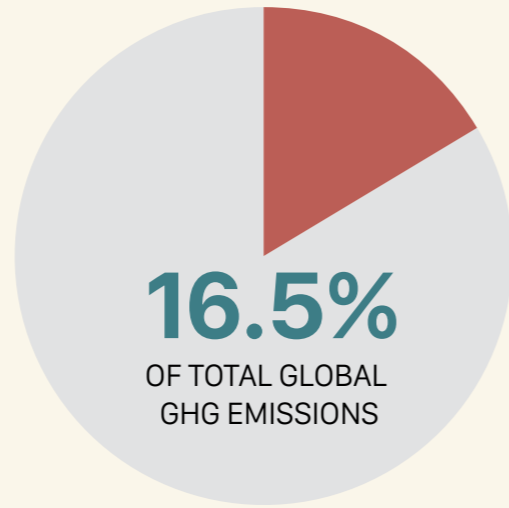
According to the UN FAO, a third of all food produced in the world is lost or wasted every year.<sup>99</sup> The fraction of animal-based foods wasted is small compared to other foodstuffs in terms of weight: 19% of meat and 18% of milk produced, compared to 63%, 42% and 26% respectively of all roots and tubers, fruits and vegetables, and cereals.<sup>100</sup> In this context, GHG emissions embodied in global food loss and waste amount to 2.7GtCO<sub>2eq</sub> (3.49GtCO<sub>2eq</sub> if embodied emissions from deforestation and organic soils are included).<sup>101</sup> Despite the smaller contribution to food waste by weight of animal-based foods, its contribution to the total embedded environmental impacts is much larger, given their higher environmental footprint.

In fact, milk was found to be the highest contributor of any commodity to GHG emissions embodied in food waste, followed by grains and then meat, with proportionately distributed GHG impact costs. Meat

# THE LIVESTOCK SECTOR IS RESPONSIBLE FOR...

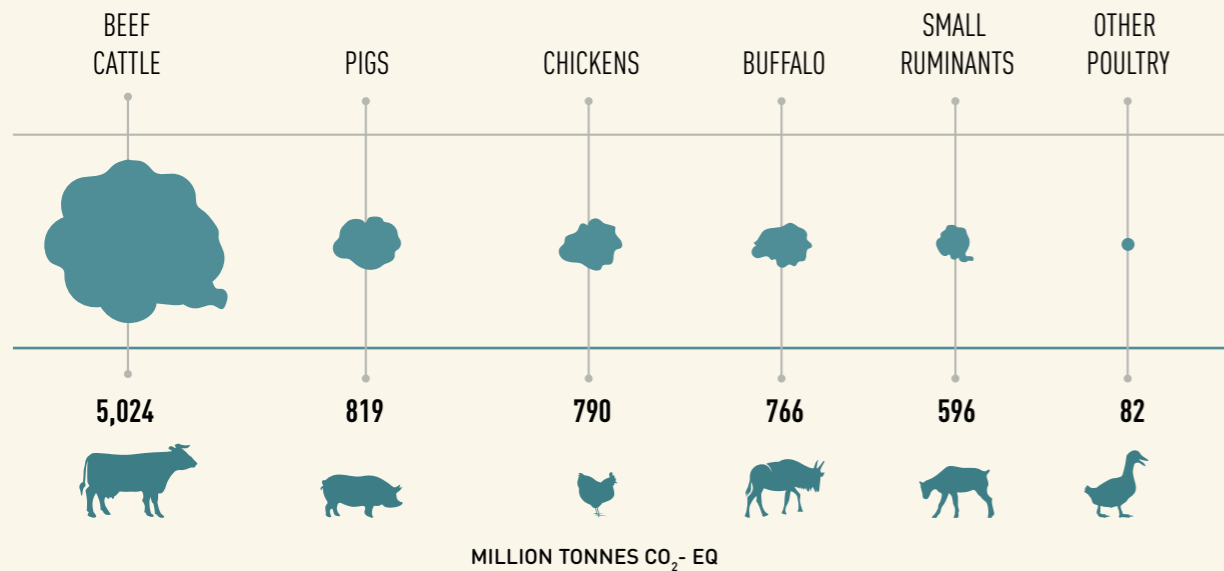
**8,100\*** MtCO<sub>2</sub>e /year

\* It includes all emissions across the livestock production value chain

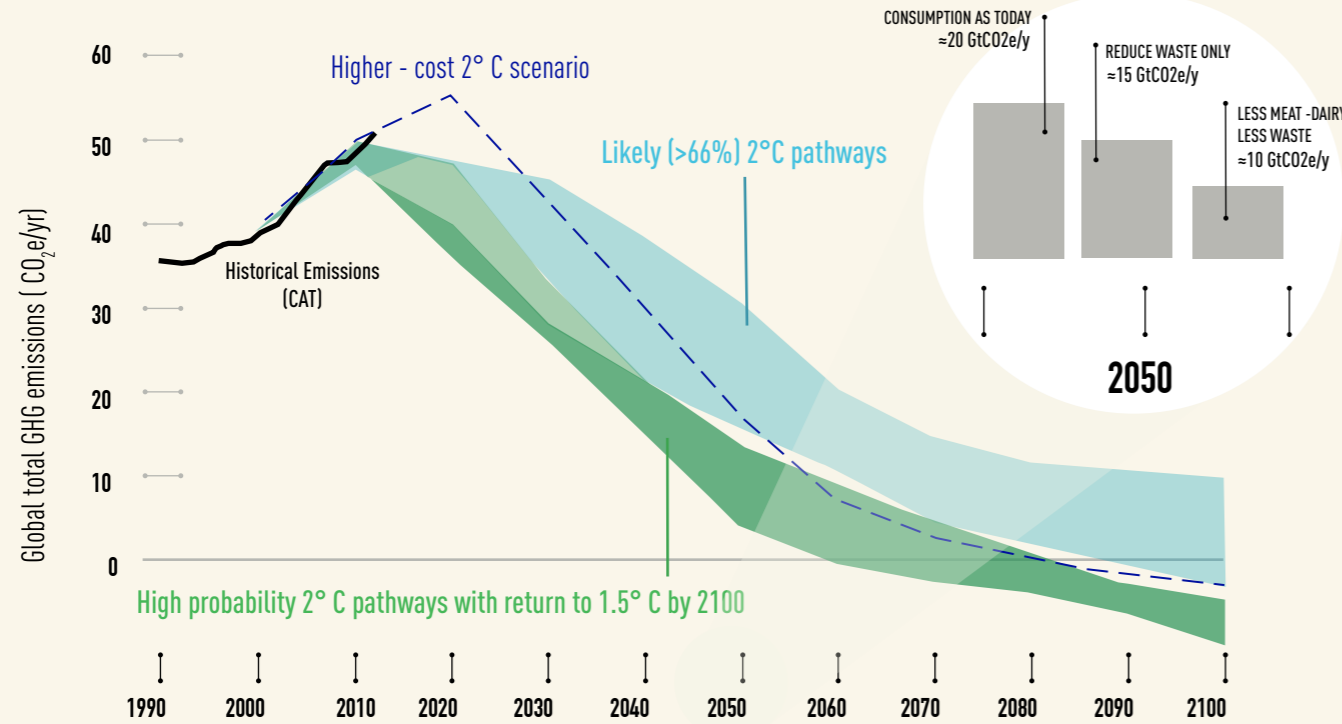


## TOTAL GHG EMISSIONS BY LIVESTOCK TYPE

Source: FAO (GLEAM 2.0)

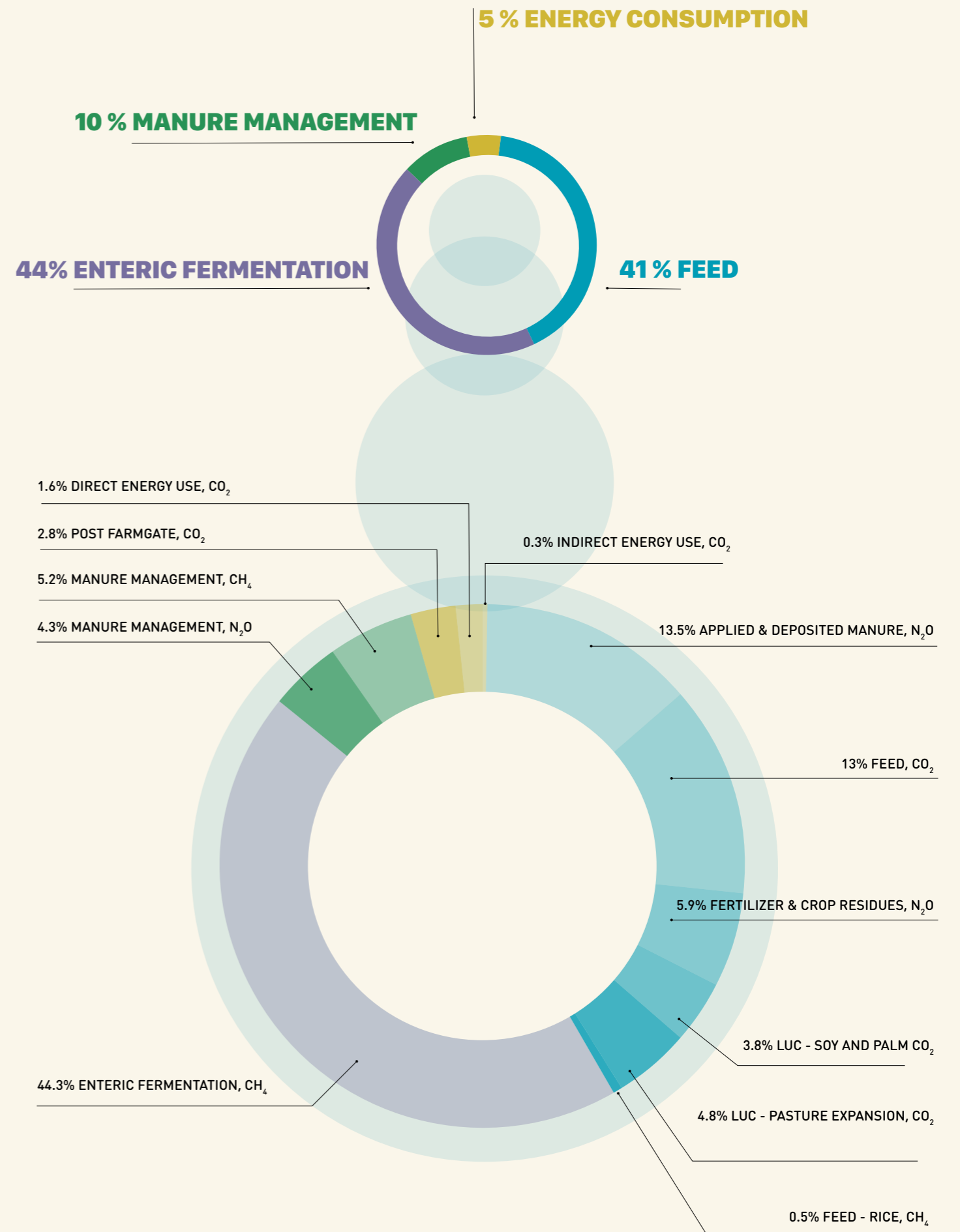


## 2050 GHG EMISSION SCENARIOS ASSOCIATED WITH AGRICULTURE AND LUC VS REQUIRED GHG EMISSION REDUCTION TRAJECTORIES



## GHG EMISSIONS FROM LIVESTOCK BY SOURCE (PERCENTAGE)

Source: FAO (GLEAM 2.0)



and milk were the highest contributors to total land occupation, although the majority of this land, when compared to their cropland occupation, can be seen to be grasslands or pasture. Meat's water scarcity costs were the largest for any commodity. The costs associated with the externalities of meat and milk production on erosion, water pollution and biodiversity and ecosystems were also considerably higher than for any other commodity.

As such, significant reductions in animal-product waste must be part of a more sustainable pattern of consumption. Nevertheless, even if all animal food product waste could be eliminated (i.e. 20%), current consumption levels would still be too high to allow for more sustainable livestock production. A study exploring a number of scenarios for sustainable meat and milk consumption in 2050 estimates that the average per-capita consumption would need to be reduced to 12kg and 26kg per year for meat and milk respectively (or 20kg of meat and either 43kg of milk or 4.3kg of cheese at today's levels) to allow livestock production to be sustained purely through efficient use of grasslands, wastes and cropland not required for human food.<sup>102</sup> This level of production is referred to as 'default livestock', as livestock production at such low levels would make the most efficient use of existing land and feed sources.

## 3. Land use, deforestation and biodiversity loss

*The livestock sector has grown at an unprecedented scale over the last decade. Humans are now rearing over five times more animals than in 1960.<sup>103</sup> Weighing 25 times more than all wild land animals combined, the livestock population has been referred to as the leading cause of modern species extinctions.<sup>104</sup> Even without the significant increases forecast in animal food production, just maintaining current levels is radically incompatible with the global SDGs and biodiversity targets. In this context, the urgent transformation towards lower livestock production - including supporting the major dietary change and waste reduction measures argued for earlier - is required to maintain the ecosystems that support it.*

### 3.1. Livestock and the global biodiversity crisis

Currently, the Earth's biodiversity is facing a crisis almost unprecedented, except by previous global mass extinction events. Modern extinction rates are estimated to be 1,000 times the natural background rate.<sup>105</sup> On average, global populations of vertebrate species have halved in the last 40 years, while freshwater species have declined by 76%.<sup>106</sup> Fish populations utilised by humans have also halved on average over this period of merely two human generations.<sup>107</sup>

Due to its enormous scale and connectivity to so many environmental issues of concern, the consumption and production of animal-based foods is one of the most important stressors on biodiversity globally, and so is central to addressing this crisis. Directly or indirectly, it contributes to habitat loss (including deforestation); land degradation; overexploitation of natural resources; environmental pollution; invasive species, climate change and human vs. wildlife conflict. Consequently, the livestock sector profoundly impacts on ecosystems and biodiversity at a planetary scale.<sup>108,109</sup> By one measure, it has been estimated to account for about 60% of human-caused biodiversity loss on land.<sup>110</sup>

If internationally agreed goals to halt biodiversity loss (such as those set out in the Aichi Biodiversity Targets and, more recently, the SDGs) are to be achieved, significantly reducing this sector's outsized environmental impact is essential.



### 3.2. Livestock species dominate the Earth

Animal-based food consumption has increased rapidly worldwide; so too has the population of animals farmed or slaughtered to service this growing demand. The curious consequence of this is that species farmed for human consumption are now exceeding the population of any other animals on Earth.<sup>111</sup> Illustrating this new ecological dominance, it has been estimated that the collective weight of global livestock is more than 25 times that of all wild land animals combined.<sup>112</sup> Unfortunately, wild species have paid the price of their 'success'; the primary underlying driver of livestock-related biodiversity loss is the sector's monopolisation of global land use and associated resources.

Today, the global land area used to provide feed, fodder or grazing for livestock is three times higher than that of all land-based protected areas for conservation globally combined.<sup>113,114</sup> This contrast reflects a long history of habitat destruction, through agricultural expansion, into lands once occupied by a variety of natural ecosystems.<sup>115</sup>

### 3.3. A major driver of deforestation and habitat destruction worldwide

Livestock production has been described as the predominant driver of natural habitat loss worldwide.<sup>116</sup> Production of animal products has been linked to 65% of global land-use change between 1961 and 2011, requiring an additional 439 million hectares of agricultural land to be brought into production - an area greater than all of India.<sup>117</sup> Much of this has come at the expense of high-biodiversity-value habitats, such as tropical forests.<sup>118</sup> Expansion of pastures is also recognised as a regional driver of wetland and mangrove destruction - both habitats of high biodiversity value that have seen large declines in size in recent decades.<sup>119,120</sup>

Livestock are estimated to be at the root of 60% of human-caused biodiversity loss on land, due to land occupation and habitat destruction.<sup>121</sup> This impact will surely increase if, as projected, global land use for grazing and crops grows much further in the absence of measures to reduce overall meat and dairy demand (see Chapter 2). This will be compounded by the fact that most newly created agricultural land globally is concentrated in tropical countries, where biodiversity is greatest.<sup>122</sup> In 2050, using current agricultural technology to feed 9 billion (the forecast global population) a Western-style diet rich in animal foods would require global cropland areas to almost double.<sup>123</sup>

It is therefore clear that, to stop future habitat destruction through agricultural expansion, moderation of dietary demand for animal-based foods will be necessary. Recent modelling studies have further confirmed this.<sup>124</sup> One such study concluded that human diets play a decisive role in making the twin goals of halting deforestation by 2050 while still being able to feed the world mathematically possible. At one end of the spectrum, all 500 scenarios considered were found to be biophysically possible if a vegan diet was adopted globally; at the other, only 15% of scenarios might be possible through global adoption of a US-style high-meat diet. Significantly, the study identified a fundamental trade-off between environmental benefits and meat consumption: we cannot stop deforestation and shift to organic agriculture, which is better for farmland biodiversity, without significantly reducing meat consumption.<sup>125,126</sup>

### 3.4. Soy production for animal feed: an ongoing threat to the Amazon

Animal agriculture is both a direct and indirect driver of deforestation through pasture and cropland expansion into forests, respectively, for animal feed. Grazing in forests is also recognised as a minor cause of forest degradation in Africa and the Americas.<sup>127</sup> Through these processes, the livestock sector has been linked to 30% (72.7 million hectares) of global deforestation in the period 1990 to 2008. Of that total, 80% resulted from pasture expansion for ruminants, 14.5% for crops fed to monogastric pigs and chickens, and 5.5% for crops fed to ruminants.<sup>128</sup>

According to WWF, soy production has expanded more rapidly than any other global crop over the last 50 years; it has increased from 27MT to 269MT, and could reach 515MT by 2050.<sup>129</sup> Argentina, Bolivia, Brazil and Paraguay are responsible for 99% of Latin American soy production,<sup>130</sup> and represent 97% of soy-related deforestation worldwide,<sup>131</sup> the majority of which is embodied in exported crops.<sup>132</sup> Three-quarters of global soy production is destined for use in animal feed as the mainstay source of protein supporting the industrial model of pig and poultry production worldwide.<sup>133</sup> Globally, the top two soy-importing regions are China and the EU; in 2013/14 they accounted for 63% and 12% of global soy imports respectively, used to support their large domestic livestock industries.<sup>134</sup> The average European consumes approximately 61kg of soy per year, largely indirectly through animal products such as chicken, pork, salmon, cheese, milk and eggs.<sup>135</sup>

Importantly, soy production does not just affect tropical forests. In the last few decades, vast areas of highly biodiverse grasslands and savannah have been converted to agriculture. In South America, the area of land devoted to soy production grew from 17 million hectares in 1990 to 46 million hectares in 2010, mainly on land converted from natural ecosystems. Driven by increasing global demand for animal foods, global soy production is projected to double by 2050, corresponding to a likely 50% increase in the land area devoted to it. This will put large areas of savannah and grassland ecosystems suitable for soy cultivation in both South America and Africa at further risk.<sup>136</sup>

### 3.5. Livestock's huge demand for natural resources

Importantly, the livestock sector's appropriation of a large amount of wild plant and animal biomass also impacts on ecosystems and biodiversity. This is ecologically significant because species diversity in a region is correlated with its available energy - for which biomass is a measure.<sup>137</sup> In short, if less energy is available, an ecosystem can support fewer species - and with lower populations. This concept is illustrated by the competition for forage between livestock and wild herbivore species, which has been demonstrated to affect numbers of wild species and their predators in both Asia and Africa.<sup>138</sup> Of all the plant biomass utilised by humanity each year, 60% is used to feed or provide bedding for livestock, while just 12% is embodied in plant-based foods for human consumption.<sup>139</sup>

Fishmeal and fish oil are further examples of the livestock sector's biomass demands. Forage fish species low down in the food chain are ecologically important prey species, especially for marine mammals and seabirds.<sup>140</sup> Although most wild-caught fish are used for direct human consumption, about 10% of the global catch is currently used for the production of fishmeal and fish oil.<sup>141</sup> The primary consumers of this resource today are carnivorous fish species produced in the rapidly growing global aquaculture sector, which in 2010 consumed 73% of global fishmeal (up from 2% in 1960),<sup>142</sup> and in 2012 consumed 74%

of global fish oil production.<sup>143</sup> In contrast, pigs and chickens consumed 20% and 5% respectively of global fishmeal in 2010, down from almost 50% each in 1960.<sup>144</sup>

Conflict between humans and wildlife is another important way in which animal agriculture impacts on global biodiversity. Carnivore species in particular, which require large prey and habitats to support their metabolisms, have been hunted to regional extinction worldwide, primarily to protect livestock from predation. Familiar examples include the lynx in Western Europe and the grey wolf in Europe and the Americas. Research has recently demonstrated that top predators play an essential role in regulating competition within ecosystems – all the way down to plants – so long-term impact of this hunting on ecosystems worldwide is likely to be significant beyond only carnivore species.<sup>145</sup>

### Animal agriculture and the geography of deforestation

Although animal agriculture's contribution to global deforestation has been significant, the geography of this impact is regionally specific. To date, the vast majority of livestock-related deforestation has taken place in Latin America; in Brazil, for example, 19% of the Amazon region has been deforested since the 1970s, of which 62% was being used as pasture in 2008. The environmental cost of this expansion has been significant. One recent study attempted to estimate the unpriced natural capital costs to society from the Brazilian cattle and soy industries, and found that, for every US dollar of revenue made, cattle ranching costs society a further 22 USD, and soybean farming costs a further 2 USD.<sup>146</sup>

In Costa Rica, nearly half of tropical forests have already been cleared and are now dedicated to livestock production. Looking more widely throughout Latin America, between 2011 and 2013, 57% of new pastureland replaced forests.<sup>147</sup> Together, Argentina, Bolivia, Brazil and Paraguay incurred over 80% of forest loss in Latin America in the 2000s, accounted for 73% of total beef production and comprised 83% of the region's beef exports.<sup>148</sup>

In commercial agriculture in the region, the dominant drivers have been producing beef, leather, soy and other commodities responsible for two-thirds of deforestation between 2000 and 2010. Elsewhere in the world, other commodities such as palm oil are the dominant direct drivers of deforestation, and local or subsistence agriculture plays a greater role.<sup>149</sup> Interestingly, 'palm kernel meal' – a by-product of palm-oil production – enters the livestock supply chain as a low-value feed ingredient, mostly exported from South East Asia to the EU and New Zealand.

The majority of beef produced in Latin America is still consumed in domestic markets, but the 2000s saw sharp increases in beef exports, especially in Brazil,<sup>150</sup> which became the world's largest beef exporter (a status it still retains) when its exports grew by approximately 500% between 1999 and 2009.<sup>151</sup> Despite this, about 80% of Brazilian beef is still consumed domestically.<sup>152</sup> The opposite pattern is observed for beef's co-product, leather: 74% of Brazilian leather was exported in 2009,<sup>153</sup> but its contribution as an overall economic driver of deforestation is considered to be small compared to beef.

### 3.6. Livestock's large water footprint

The depletion and pollution of water sources associated with livestock production also plays an important role in biodiversity loss and environmental damage. Animal agriculture is responsible for one-third of all freshwater use.<sup>154</sup> Above all, increased water demand arises from the needs of irrigated feed-crop production

# BREAKDOWN OF GLOBAL DEFORESTATION CAUSES



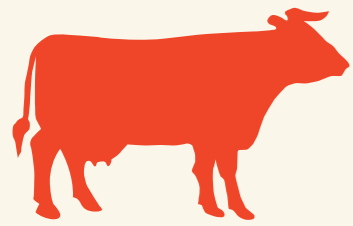
DEFORESTATION CAUSE (1990-2008)	AREA DEFORESTED (MHA)	% OF GLOBAL	% OF AGRICULTURE
ALL	239.3	100	N/A
AGRICULTURE (ALL)	127.6	53	100
LIVESTOCK PRODUCTION (ALL)	72.7	30	57
RUMINANT PRODUCTION (ALL)		27	49
ANIMAL PASTURE	58.2	24	46
SOY BEANS	13	5	10
CROP PRODUCTION	69.4	29	54
CROPS: RUMINANT FEED			3
CROPS: PIG & POULTRY FEED			8
CROPS: FOOD, FIBRE & FUEL			43

Source: European Commission

# EARTH'S LAND MAMMALS

BY WEIGHT

● each equals one million tons



**520**  
CATTLE



**39**



**358**  
HUMANS



**136**  
SHEEP



**49**



**90**  
PIGS



**34**



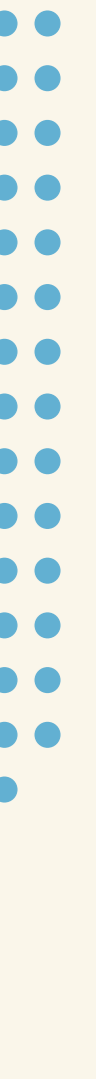
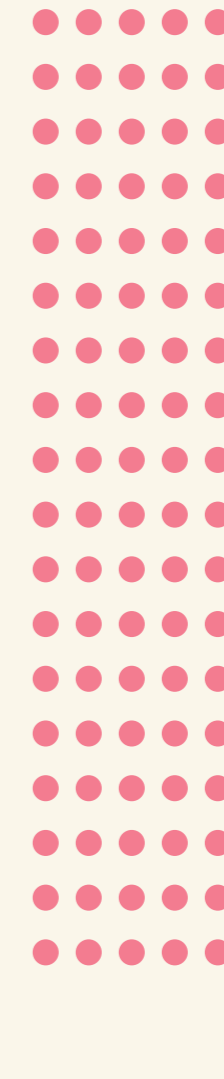
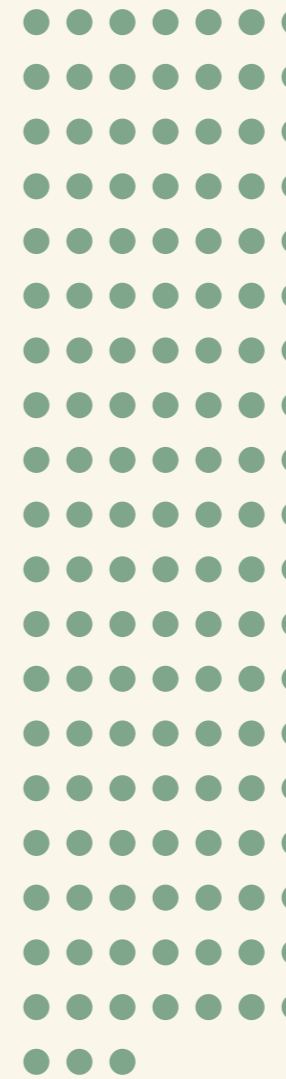
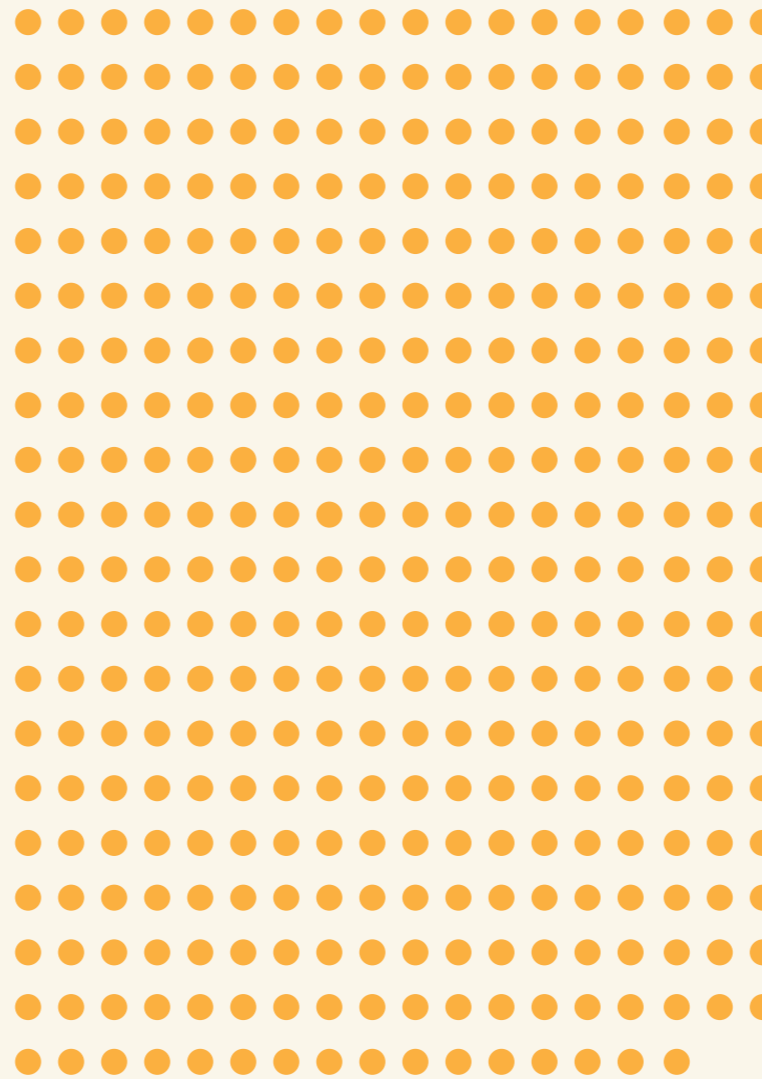
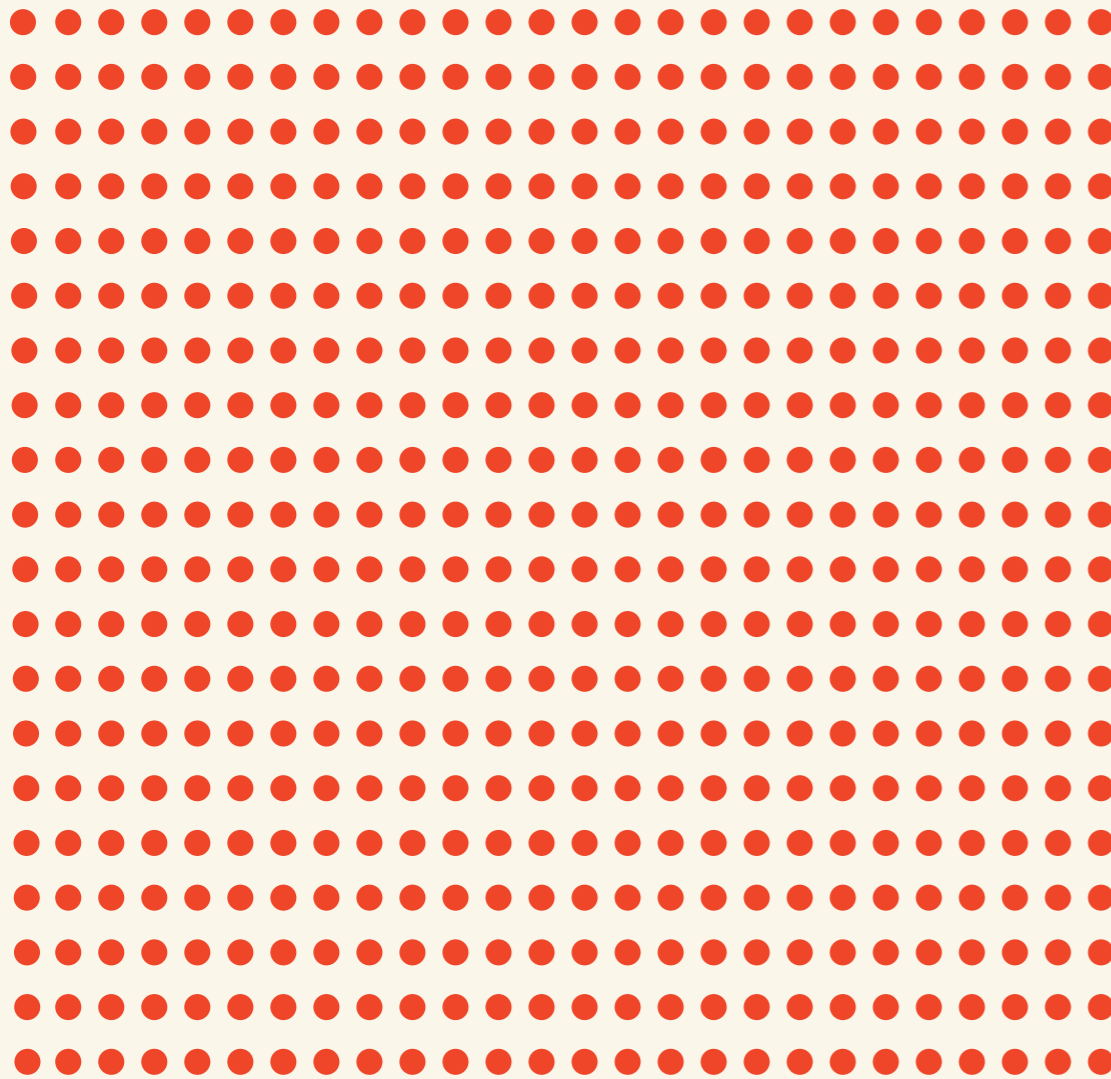
**29**

PETS

GOATS

WILD ANIMALS

HORSES





and grazing areas. Animal-feed production is estimated to represent around 7% of all global water use, 50% of all water used in total food production and 15% of all water in irrigated areas. This is particularly driven by an increase in intensive livestock production methods, for which animal feed depends on barley, maize, wheat and soybean crops.<sup>155</sup>

In addition, significant water pollution is associated with discharges from livestock production (nitrogen, phosphorous pollution from fertilisers on pasture and feed crops, large disposal of manure, pesticides due to feed production, etc.).<sup>156</sup> This has led to dead zones being formed in areas most affected (the Mississippi Delta that leads to the Gulf of Mexico, the Baltic Sea, etc.). Even in less extreme cases, the impacts are still significant and the costs associated with rectifying this type of environmental contamination are high. In New Zealand, the upper-end estimate is similar to the total value of dairy exports at 8.5 billion USD. In the EU, the costs for cleaning up excess nitrogen for the whole agricultural sector range between 20 and 150 billion EUR.<sup>157</sup>

Moreover, large farms are also a source of drug residues, such as antibiotics and hormones (given to animals for therapeutic or prophylactic reasons) and heavy metals (such as copper, zinc, selenium, cobalt, arsenic, iron and manganese). Finally, processing livestock products (meat and offal processing and rendering processes in the slaughterhouse/agro-food industries) and the tanning process of heavy and light leather also put pressure on water resources.

### 3.7. Livestock impacts on soil nutrients

Traditionally, animals played a positive role in an integrated farming system, as their manure was used in small quantities for soil fertilisation. However, this has changed with the rise of intensive farms. One of animal agriculture's most important environmental impacts, affecting global ecosystems and biodiversity, is its role as a driver of environmental pollution through the release of excess nutrients as nitrogen and phosphorus into the natural environment.<sup>158</sup>

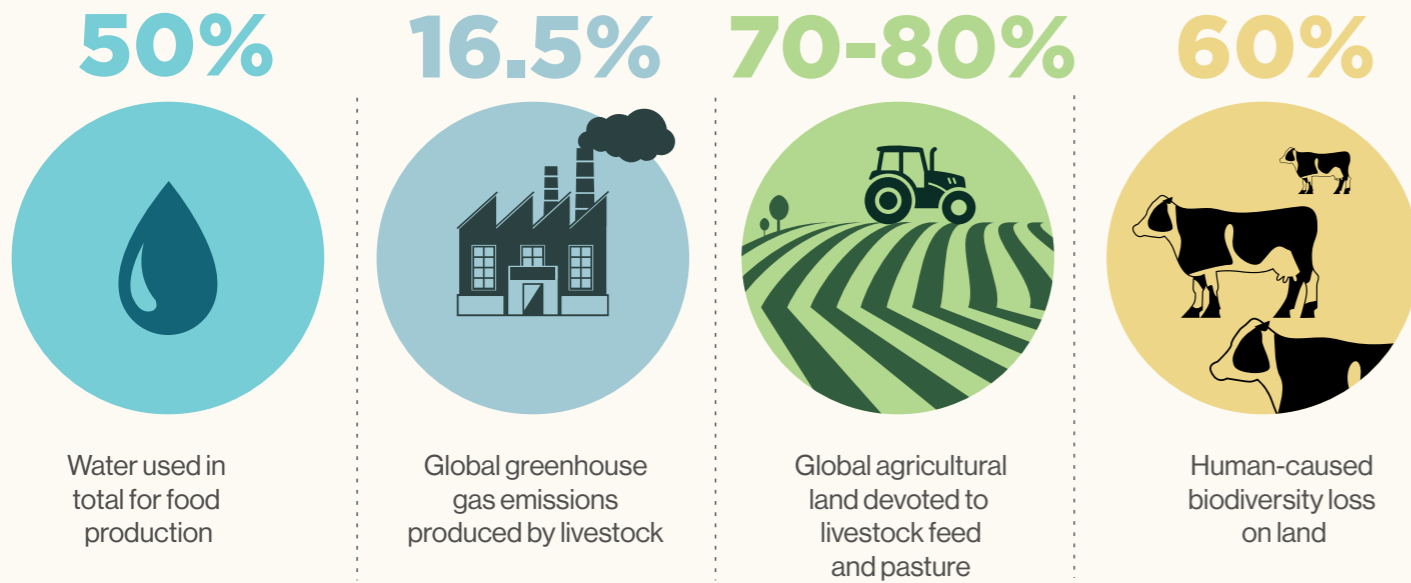
At the core of the problem lies the fact that livestock is inefficient at using nutrients to make human food, due to environmental nutrient losses occurring during the growth of feed and fodder. This is compounded further by the fact that livestock convert less than 11% of nitrogen and 19% of phosphorus from their feed into human-edible food.<sup>159</sup> Consequently, animal-based foods have large nutrient footprints, with the average nitrogen footprint being some 10 times that of plant-based foods.<sup>160</sup> For phosphorus, 72% of the global average dietary footprint between 1961 and 2007 can be attributed to animal-based foods.<sup>161</sup> Overall, 80% of the nitrogen and phosphorus contained in crops and grass consumed by livestock globally provides only around 20% of the nitrogen and phosphorus contained in human diets.<sup>162</sup>

To address the impact of nutrient pollution on global biodiversity, it has been proposed that a globally sustainable level of nitrogen and phosphorus use would be approximately half that currently used by humanity.<sup>163</sup> This in itself would require substantially increased production efficiency and dietary consumption changes. However, if projected growth in population and per-capita meat and dairy consumption is realised, it is anticipated that global nutrient-related pollution might increase by a further 40-50% in 2050.<sup>164</sup>



# THE LIVESTOCK SECTOR IS RESPONSIBLE FOR...

Source: FAO



## 4. Impacts on health and food security

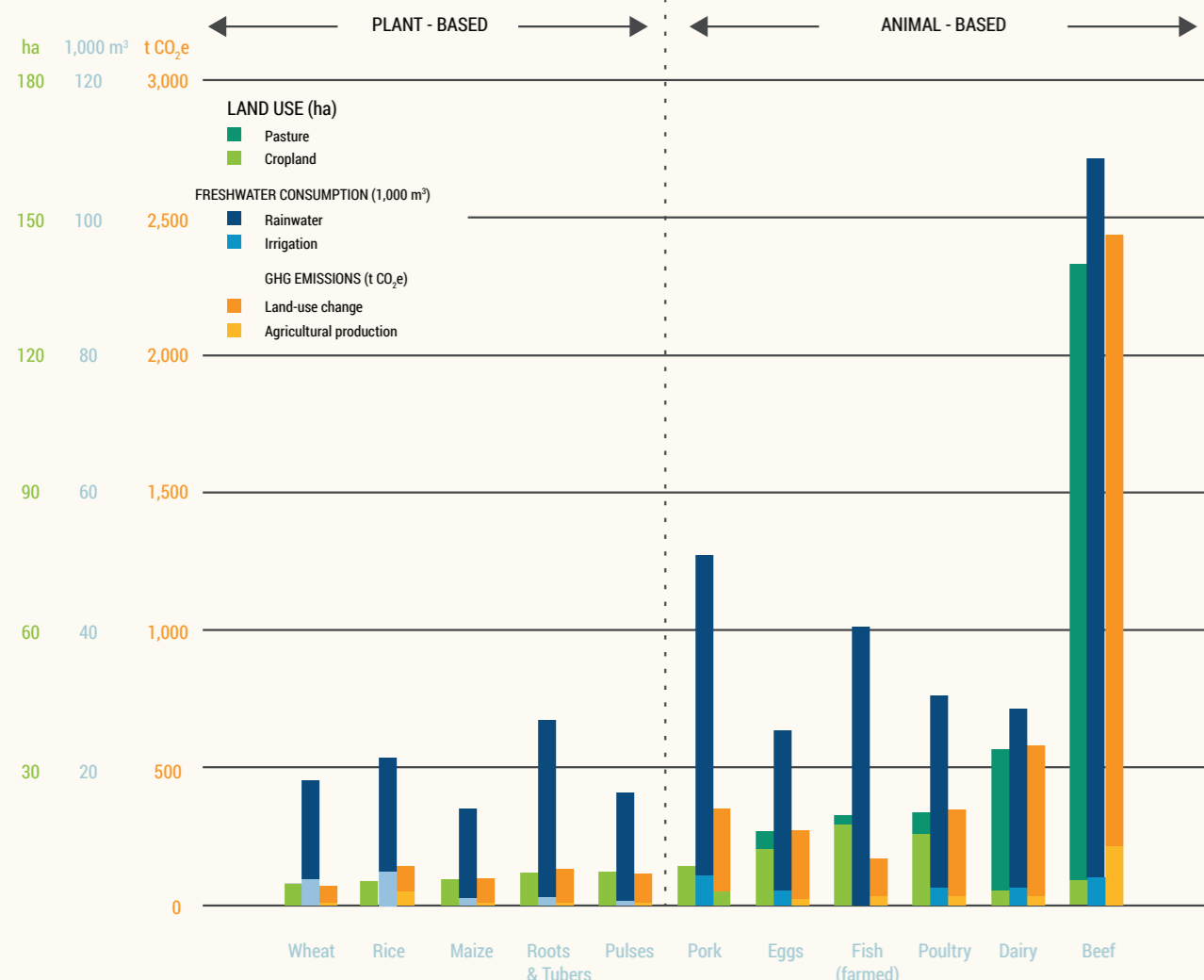
Today's consumption of meat and dairy products in the Global North is estimated to be two to three times higher than that which is considered healthy. Levels are also rising rapidly in the majority of developing economies.<sup>165</sup> Such consumption patterns are associated with increased incidence of diet-related disease, including obesity, heart disease, diabetes and certain types of cancer, as well as a significant number of foodborne disease cases.<sup>166</sup> In addition, the intensification of production methods for livestock poses significant threats to public health as a major driver of antimicrobial resistance (AMR) and zoonotic disease outbreaks. These issues make a further compelling case for significantly reducing consumption of meat and dairy products and improving their production methods.

### 4.1. Overconsumption of livestock products and personal health

Meat and animal products are good sources of some nutrients, particularly high-quality protein, iron, selenium, vitamin B12 and omega-3 fatty acids. Alternative plant foods can also provide these nutrients, as well as high levels of fibre and some vitamins and minerals not available in significant quantities via animal products.<sup>167</sup> This is not without controversy; many argue that plant-based sources are less convenient, concentrated or available. What is not disputed is that animal products are typically high in saturated fat and cholesterol, and processed animal-derived foods, such as bacon, contain potentially harmful additives like salt and nitrates. Overconsumption of animal products, particularly processed red meat, is associated with obesity and an increased risk of non-communicable diseases (such as heart disease and type 2 diabetes<sup>168</sup>) and certain types of cancer (such as stomach, colon, rectum, pancreas and prostate cancers<sup>169</sup>).

### ANIMAL - BASED FOODS ARE MORE RESOURCE-INTENSIVE THAN PLANT BASED FOODS

PER TON PROTEIN



Source: World Resources Institute

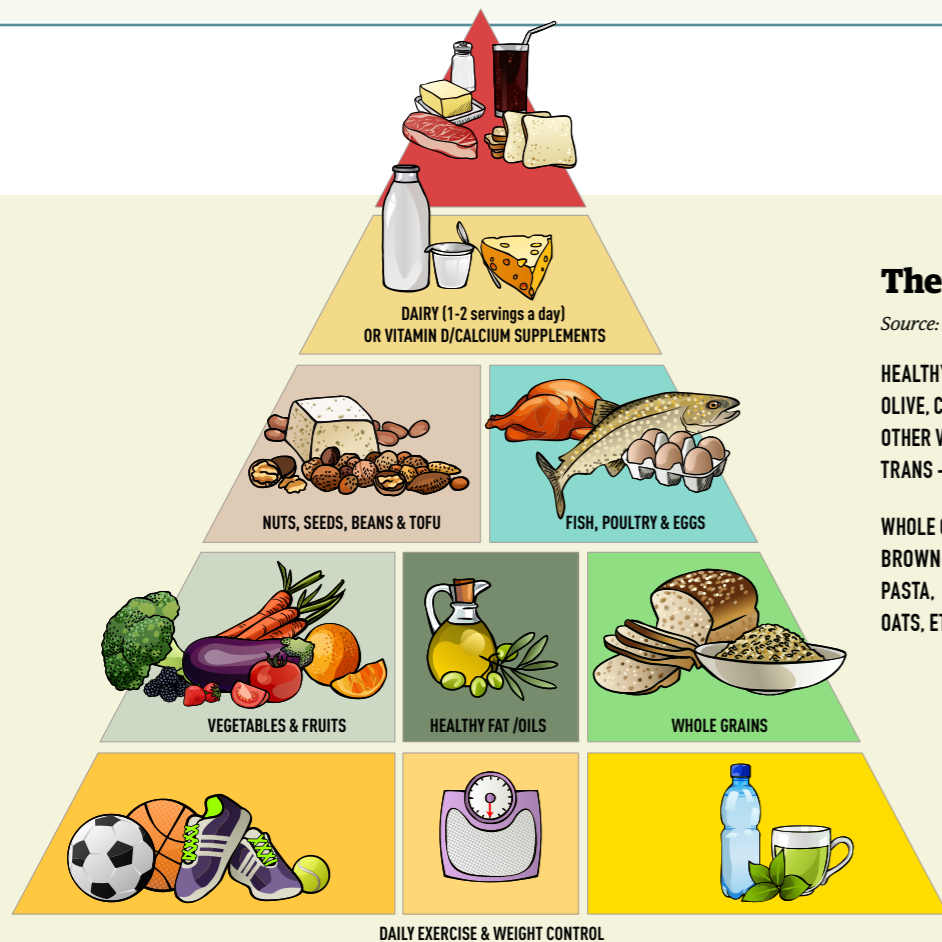
Given the balance of the evidence, the vast majority of health experts conclude that consumption of animal products – especially processed meat, red meat and dairy – should be reduced, and that of plant-based foods increased.<sup>170</sup> Despite this advice, consumption of animal products in the Global North, although stabilised, remains excessive – and continues to grow in emerging economies in line with rising incomes.<sup>171</sup>

In addition, cases of foodborne disease, particularly those related to salmonella and campylobacter infection, are often linked to the consumption of contaminated animal products, particularly meat and eggs. A 2014 study showed that a staggering 97% of the 300 chicken breasts sold in US grocery stores harboured dangerous bacteria, while more than half of the samples contained faecal contaminants.<sup>172</sup> The European Food Safety Authority estimates that there are 9 million cases of human campylobacteriosis a year in the EU, costing 2.4 billion EUR. For salmonellosis, the costs are 3 billion EUR. For both diseases, a large number of cases are foodborne.<sup>173</sup>

### Meat and cancer

The International Agency for Research on Cancer published a review in October 2015 classifying processed red meat such as bacon and sausages as carcinogenic and listing them alongside substances such as tobacco, asbestos, plutonium, alcohol and arsenic. Unprocessed red meat was classified as a 'probable carcinogenic' and listed alongside a number of chemical products and pesticides.<sup>174</sup> This led to a drop of 15-17% in sales of sausages and bacon in the UK alone in the following weeks.<sup>175</sup>

Excessive levels of consumption of meat products are thought to be associated with an increase in the number of certain diet-related types of cancer, so the benefits of reducing consumption of animal products and increasing that of vegetables is twofold.<sup>176</sup> Cancer Research UK reports that 3% of all cancers in the UK per year may be linked to excessive consumption of processed and red meat. This increases for certain types of cancer, such as bowel cancer, where it is associated with 21% of cases. Worldwide, this means around 300,000 cases of bowel cancer a year could be avoided.<sup>177</sup>



### The Healthy Eating Pyramid

Source: Harvard School of Public Health

HEALTHY FATS AND OILS:  
 OLIVE, CANOLA, SOY, PEANUT &  
 OTHER VEGETABLE OILS;  
 TRANS -FREE MARGARINE

WHOLE GRAINS:  
 BROWN RICE, WHOLE WHEAT  
 PASTA,  
 OATS, ETC.

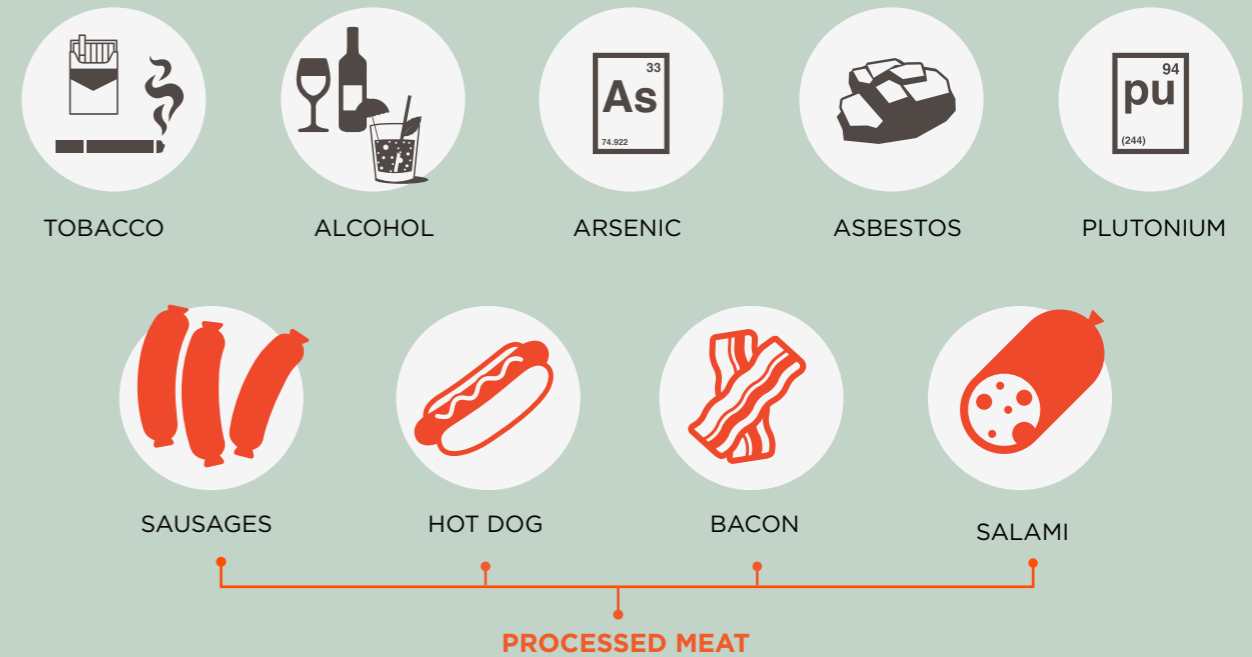


# MEAT & CANCER

THE WHO HAS INCLUDED MEAT ON A LIST OF CANCER CAUSING SUBSTANCES

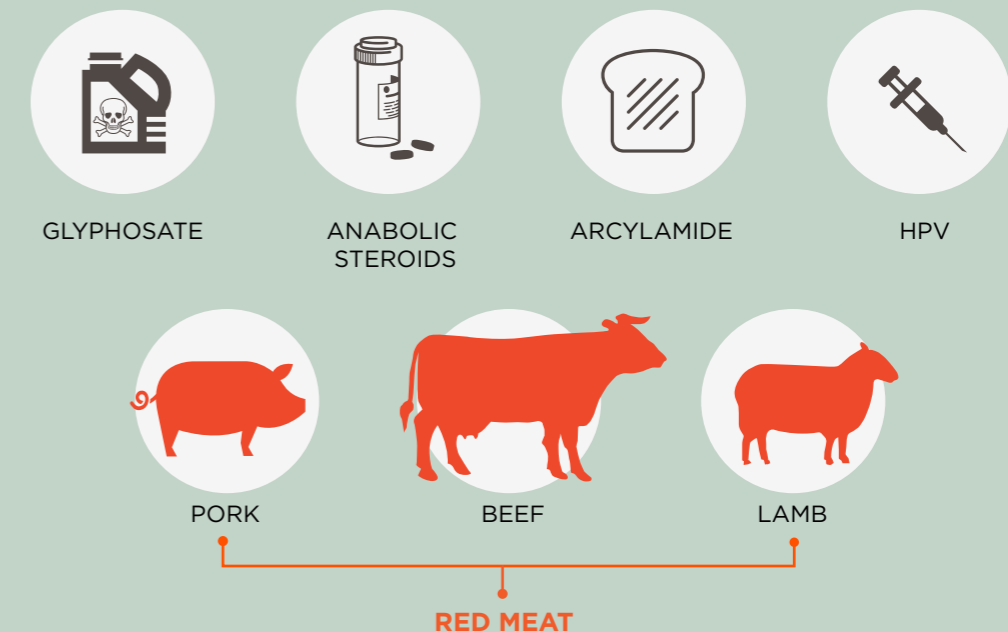
## GROUP 1

CARCINOGENIC TO HUMANS



## GROUP 2A

PROBABLY CARCINOGENIC TO HUMANS



## 4.2. Intensive production methods and public health

Intensive livestock production has been identified as one of the main drivers for the excessive and inappropriate use of antibiotics and the associated rise in AMR, especially growing resistance of bacteria to antibiotics.<sup>178</sup> The use of antibiotics in animal farming is huge – as high as 80% in the US. Their relative use in agriculture is projected to double in the major emerging economies of Brazil, Russia, India, China and South Africa by 2030. Very often, these antibiotics are given to healthy animals to make them grow faster, or for prophylactic purposes to control disease for animals grown in confined conditions. This is problematic because excessive exposure of bacteria to antibiotics drives the acquirement and spread of resistant genes, which are then passed on to human pathogens.<sup>179</sup>

In that context, there are risks associated with drug-resistant bacteria being passed on through direct contact between humans and animals, transferred via contaminated manure or water, or acquired when consumers prepare or eat the meat itself. In some countries, there is evidence that last-resort antibiotics for humans are being used extensively in animals, with a recent Chinese finding of a bacterial gene conferring resistance to colistin – a last-resort antibiotic.<sup>180</sup> This contrasts with more sustainable livestock production methods (such as organic) in which antibiotic use is restricted; this is also enabled by better living conditions, which lower the risk of infection.

The European Commission currently estimates annual AMR-related deaths to be 25,000, which is likely an underestimate, as is the 1.5 billion EUR associated with healthcare and productivity losses.<sup>181</sup> In addition, the UK-based AMR review projected that, by 2050, drug-resistant bacteria could kill 10 million people per year globally and make routine medical procedures, such as hip transplants and chemotherapy, impossible. This would cost a loss in economic outputs of up to 100 trillion USD, as well as a projected GDP decrease of 2–3.5%, by mid-century.<sup>182</sup>

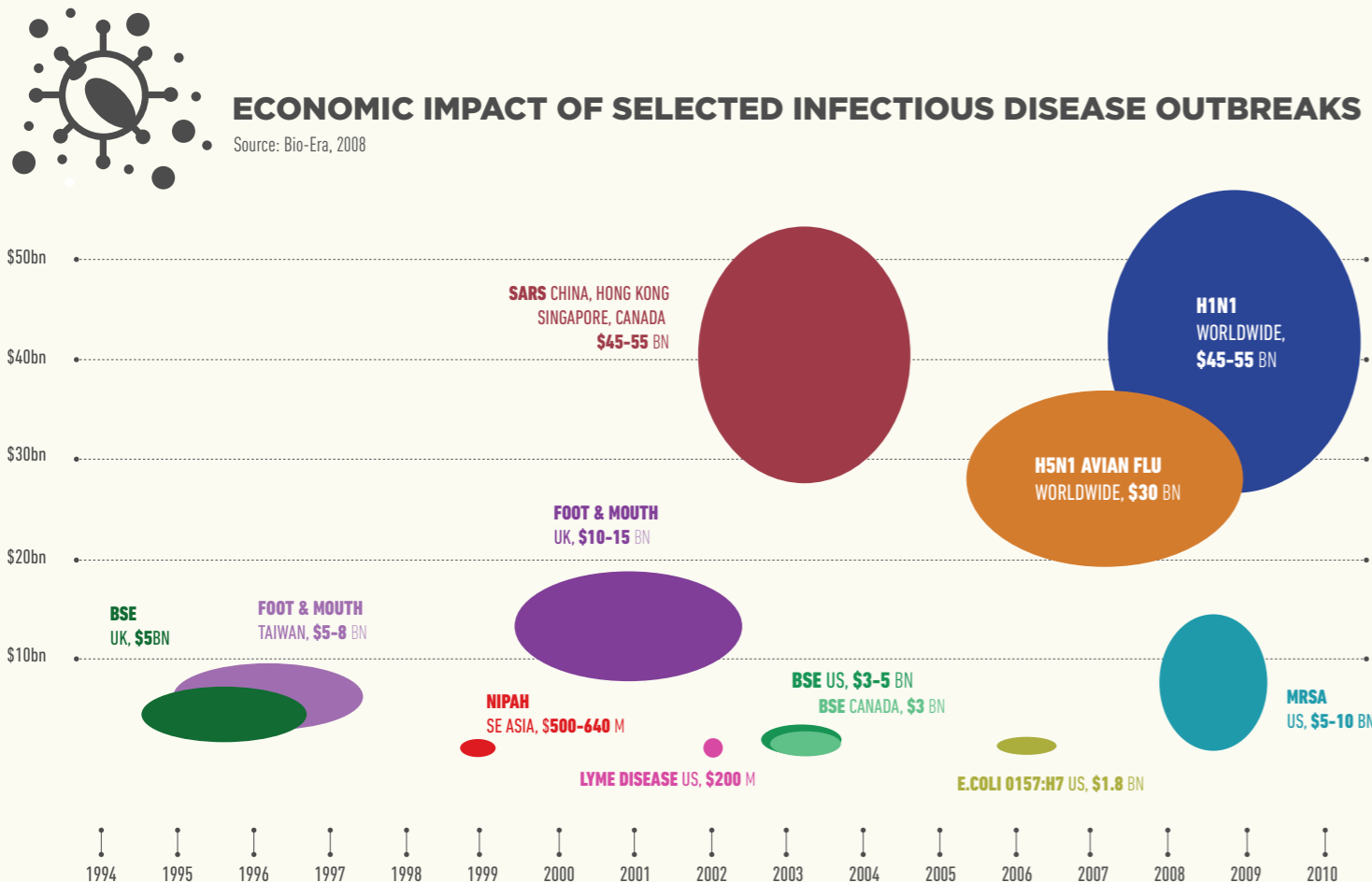
### Factory farming

As factory farms are often the incubators of zoonotic diseases and the rise of resistance in antibiotics and other micro-organisms, it's important to understand what 'factory farm' means. The term broadly refers to modern livestock production systems involving dense animal populations raised on limited land and requiring large amounts of food, water, energy and medical inputs.<sup>183</sup>

In the US, the Environmental Protection Agency defines Animal Feeding Operations (AFOs) as agricultural operations where animals are kept and raised in confined conditions and which congregate animals, feed, manure, dead animals and production operations on a small land area. To be classified as an AFO, a lot or facility must have animals that are, or will be, stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period and crops, vegetation, forage growth or post-harvest residues that are not sustained in the normal growing season over any portion of the lot or facility.<sup>184</sup> Such facilities range from large (around or larger than 1,000 beef, 700 dairy cattle, 2,500 hogs or 125,000 chickens) to medium (300–999 beef, 200–699 dairy cattle, 750–2,499 hogs or 37,500–124,999 chickens). The main animals for such operations are cows, pigs, chickens and turkeys, but their practices are also applied to sheep, goats, rabbits and various types of poultry.

Animal welfare regulations setting minimum standards for farm animal breeding conditions exist in the EU (Council Directive 98/58/EC) and the US (Animal Welfare Act). However, factory-farmed animal housing is considered unethical by many organisations because of issues associated with high stocking density, the confinement of animals in cages and crates, mutilation of their horns and tails, separation of mothers from their offspring and selective breeding, such as fast-growing broiler chickens. In addition, these farms have poor air quality, floors that are too smooth and often wet, lack of environmental stimulus, inadequate conditions for animals to undertake their normal behaviours and concentrated feed, which can lead to animal discomfort and disease (weaker bones, poor level of cardiovascular fitness, etc.).<sup>185</sup>

Factory farms facilitate the spread of disease among flocks and transmit zoonotic disease to humans, which WHO has identified as an increasing concern. In fact, 60% of all human diseases and up to 75% of newly emerging infectious diseases are thought to be of zoonotic origin.<sup>186</sup> In addition, the impacts of animal disease outbreaks can also have significant economic consequences. These are driven by negative effects for the health of animals and humans, and the financial costs to farmers and related industries of dealing with disease and of business disruption. The total costs associated with the largest global outbreaks are large: 45–55 billion USD associated with the 2009 swine flu (H1N1) outbreak, 30–50 billion USD associated with Severe Acute Respiratory Symptom (SARS) and 30 billion USD associated with avian flu (H5N1).<sup>187</sup>



### 4.3. Air pollution

Agriculture is a key source of three major air pollutants: ammonia, particulate matter and nitrous oxide emissions. Around two-thirds of all global emissions of ammonia and nitrous oxide are associated with livestock production.<sup>188</sup>

Air pollution is a serious problem for human health as it contributes to conditions such as bronchitis, asthma, lung cancer and congestive heart failure. In this context, emissions associated with the livestock sector can have a large impact on local and regional air quality.<sup>189</sup>

The related costs are considerable. For example, emissions in Denmark cause health-related costs in the order of 4.9 billion EUR per year, with agriculture contributing to around 43% of these emissions - more than twice those from road traffic (18%) and over four times those from major power plants (10%). A US study suggests that a 10% reduction in livestock ammonia emissions can lead to particulate-related health benefits valued at over 4 billion USD annually.<sup>190</sup>

#### Growing public concern for animal welfare

Beyond animal agriculture's impacts on health and the environment, there are serious ethical concerns linked to the raising and killing of such a large number of farm animals each year, approximating 9 billion in the EU alone and 90 billion globally,<sup>191</sup> predominantly in intensive farming systems. Article 13 of the Treaty on the Functioning of the EU recognises animals as sentient beings,<sup>192</sup> yet these animals - sentient, complex and capable of feeling pain, fear and frustration, as well as joy and excitement - are viewed by industrialised agriculture, in which they are often confined and typically denied the ability to carry out their instinctual species-specific natural behaviours, as commodities. As a result, these animals suffer a myriad of assaults to their physical, mental and emotional wellbeing.

A growing number of NGO-led public campaigns encourage citizens to reduce their consumption of animal-based foods, and concern for animals often scores highly as a reason for doing so. It was the leading reason given for participation in the popular campaign Veganuary; 43% of survey respondents said they took part because of animal welfare/rights, followed by health at 39% and the environment at 10%.<sup>193</sup>

The treatment of farmed animals and the conditions under which they are raised, transported and slaughtered within industrialised agriculture are incompatible with providing adequate levels of welfare. It is difficult to truly account for the degree and amount of suffering that farmed animals experience while raised in intensive confinement systems - even without addressing the slaughtering process.

In recent years, citizens have become increasingly concerned by the ethical connotations of animal farming. A 2016 Special Eurobarometer on *Attitudes of Europeans Towards Animal Welfare* found that 94% of respondents believe it is important to protect the welfare of farmed animals and 82% believe farmed animals' welfare needs to be improved.<sup>194</sup> Similarly, a 2017 US survey on attitudes towards animal farming found that 49% of US adults support a ban on factory farming and 47% support a ban on slaughterhouses.<sup>195</sup>

Much of this concern is due to widely disseminated and accessible campaigns on social media, often promoted and shared by popular public figures, as well as the release of a number of exposé films on

the animal agricultural industry (such as *Earthlings* and, more recently, *Land of Hope and Glory* and *Dominion*) and literature (such as Jonathan Safran Foer's *Eating Animals*, which has also been made into a documentary film).

In a widely-read piece in *The Guardian* newspaper Yuval Noah Harari, the acclaimed Israeli historian and author of *Sapiens: A Brief History of Humankind*, wrote: 'Industrial farming is one of the worst crimes in history'.<sup>196</sup>

As the conditions in which farmed animals are raised and slaughtered continues to be a growing concern for citizens, so this issue should be of increasing importance to decision-makers. Governments should beware of promoting sustainable intensification and the use of technology to further manipulate animals to serve our needs, as consumers increasingly demand more humane and plant-based products.

By reducing the total number of animals raised for food, a greater emphasis can be placed on sustainable agriculture and increasing support for farmers who treat the animals they keep humanely. Rural economies can prosper when consumer spending is distributed more to individuals who show a greater respect for animals and their welfare requirements. The result will be more farmers on the land and a proportional decrease in factory-style farms.



## 5. A concentrated industry

*This chapter identifies key market players along the livestock sector's value chain. The global value of the livestock sector is estimated at 1.4 trillion USD and it supports 1.3 billion people, many of them subsistence farmers. The industry is increasingly dominated by fewer players, as big companies continue to expand across markets via mergers and acquisitions and intensify their operations. The climate impact of these companies is huge. GRAIN recently reported that the world's top five meat and dairy corporations combined are now responsible for more annual GHG emissions than Exxon, Shell or British Petroleum (BP).<sup>197</sup> The same study also showed that most of the top 35 global meat and dairy giants either do not report or underreport their emissions, and that only six companies pledge cuts in supply-chain emissions - while simultaneously pushing for growth.*

### 5.1. The livestock supply chain

#### 5.1.1. Livestock in the global food chain

The livestock supply chain covers all the activities required to bring a product (live animals, meat, milk, eggs, leather, fibre, etc.) to consumers, including the different phases of production, processing and delivery. The way livestock supply chains operate has traditionally differed across countries in line with the specific environmental, cultural and socioeconomic drivers in place, which determine how livestock is produced and the required resources available.<sup>198</sup>

However, increasing supply-chain globalisation is removing many such differences. Traditional livestock production systems in the Global South (those integrated into agriculture production, distributed among many owners and in proximity to feedstocks) are gradually being industrialised (becoming segregated from agricultural production and increasingly dependent on external inputs). Trade in livestock products has also grown, and livestock producers are increasingly competing in a global market.

In addition, there have been major organisational changes in the way animal products are being procured, processed and marketed.<sup>199</sup> Companies are seeking economies of scale and greater efficiency and growth through mergers and acquisitions. Although production of livestock products, particularly beef, is highly dispersed, associated processing and distribution activities are increasingly vertically integrated, with meatpacking companies moving into food manufacturing and wholesaling. Multinational market players are also integrating horizontally; for example, liquid milk suppliers are extending into new, value-added product categories such as cheese, butter, yoghurt and infant formula.

The marketing stage of the chain is more mixed. While there are a relatively small number of supermarkets, the food-service sector is far more fragmented. Despite the presence of major global players in the latter (such as McDonald's and Burger King) accounting for significant sales of processed beef products,<sup>200</sup> the wholesale market remains important, as many businesses don't have the scale to form their own direct supplier relationships.

### 5.1.2. Livestock products as traded commodities

The role of the agricultural sector as a share of the global economy is falling. Even though the total value of agricultural exports has increased tenfold since the 1960s, its share in the value of all traded goods has decreased from 24% to 10% over the same period. This has driven a shift in trade and production towards the highest-value commodities (such as animal products) - to the detriment of lower-value plant-based agricultural commodities (such as grains).<sup>201</sup>

The world's major producers of bovine meat in 2017 were the US (11.9MT), Brazil (9.5MT), the EU (7.9MT) and China (7.6MT), each with 10% or more of global production (70.8MT).<sup>202</sup> China was the largest importer of bovine meat (1.6MT), followed by the US (1.3.MT), Japan (0.8MT), Russia (0.6MT) and Korea (0.5MT), while the biggest exporters were Brazil (1.9MT), India (1.7MT), the US (1.5MT), Australia (1.4MT) and New Zealand (0.5MT).<sup>203</sup>

The 2017 global pork market was influenced strongly by growing Chinese demand. Global pork production stood at around 118.7 MT, with China's appetite for pork making it both the top producer (54.3MT) and importer (2.1MT). Other major producers of pig meat included the EU (23.4MT) and the US (11.6MT), followed far behind by Vietnam, Brazil and Russia (around 4MT each). The top importers of pig meat after China were Japan (1.5MT), Mexico (0.9MT) and Korea (0.6MT). The EU (2.8MT), the US (2.4MT), Canada (1.3MT) and Brazil (0.9MT) were the top world exporters.<sup>204</sup>

Equally, robust Chinese demand drove trade in poultry meat in 2017. The top producers of broiler meat worldwide, which currently stands at 120.5MT, are the US (22MT), China (17.7MT), the EU (14.6MT) and Brazil (13.6MT). China was the leading net importer of poultry meat (1.4MT), followed by Japan (1.3MT), Mexico (1MT), the EU and Saudi Arabia (0.9MT).<sup>205</sup>

Global egg production has doubled since 1993 to a volume of 68.3 MT in 2013. The largest producer by far is China, which produces almost one-third of eggs globally (24.8MT). The fragile nature of eggshells means they are normally transported over relatively short distances, mainly to neighbouring countries, unless they are in processed form.<sup>206</sup>

Although not an animal product, trade in soy is strongly associated with demand for animal products, as 75% of the world's soy production is destined to feed chickens, pigs, cows and fish. The largest global

soy producer is the US, followed by Brazil and Argentina. China and the EU are the biggest soy export markets, receiving 40% and 20% of global exports respectively. While soy imports are closely associated with trends in animal production in both China and the EU, in the EU the biodiesel market is also a key driver for demand.<sup>207</sup>

## 5.2. Key market players in the livestock sector

### 5.2.1. Farmers

Farmers are at the heart of the production of animal feed and livestock. Representing 40% of global agricultural GDP, the livestock sector is a major source of income for farmers across the world.<sup>208</sup> In the EU, for example, the economic contribution of the livestock sector is estimated at 168 billion EUR annually. On average, the livestock sector represents around half of total agricultural economic activity, although it represents a higher share in countries such as Belgium, Denmark, Ireland and the UK.<sup>209</sup>

Traditionally owned by independent farmers, economic interest is driving livestock production's recent trend towards consolidation and upscaling of operations in the farming sector. One such example is a recent Chinese-Russian joint venture in which 100,000 cows will be bred in a Chinese 'super-farm' in the city of Mudanjiang to supply the Russian market. China's Zhongding Dairy Farming and Russia's Severny Bur are behind the project, and feed for the cattle will be grown on 100,000 hectares of land in China and Russia.<sup>210</sup>

### Livestock production: the hidden costs of a not-so-free market

Prices for animal products are rarely within the control of farmers, who are generally price-takers. However, since World War II, livestock farmers in the Global North have received billions of dollars in subsidies through support schemes (such as the EU Common Agricultural Policy (CAP) or US Farm Bill) in an attempt to stabilise prices, increase production and guarantee farmers' incomes.

In the EU, farmers receive around 200 EUR of taxpayers' money per hectare of land.<sup>211</sup> Annual subsidies cost the EU some 58 billion EUR, representing almost half of the EU budget.<sup>212</sup> In the US, similar subsidies amount to 20 billion EUR per year.<sup>213</sup> This reliance on subsidies has led to the development of a powerful farm lobby, which has heavy control over legislators and includes professional lobby groups, such as the American Farm Bureau Federation in the US and COPA-COGECA in the EU, as well as national and regional organisations, such as the National Farmers Union (NFU) in the UK.

Some of the multimillion-dollar public affairs organisations involved in agricultural lobbying are often much closer to the interests of big agribusinesses than small-scale farmers. An *Ethical Consumer* report on the lobbying activities of the NFU (which has a declared annual income of 57 million GBP) concluded that it has changed over the years into the 'English Agribusiness Lobby' group, defending positions that are closer to the interests of large-scale farmers, big retailers and agrochemical businesses than those of small-scale farmers.<sup>214,215</sup> NFU has also spent significant amounts of money lobbying European institutions, both directly (700,000 EUR) and through its participation in its umbrella organisation COPA-COGECA (370,000 EUR).<sup>216</sup>

Farming subsidies are increasingly controversial because of their sheer size, the ways they are distributed and the lack of evidence that they bring public benefits. In the US, it is estimated that the bulk of the 161

billion USD handed out in direct payments between 1995 and 2009 went to big corporate players, with two-thirds of US farmers not receiving a cent.<sup>217</sup> Despite their policy goal of promoting rural development, these types of programmes actually drive an exodus of small farmers in favour of big corporations that employ fewer workers and source more supplies outside the local area.

In addition, a majority of governments in the Global North continue to promote the consumption of livestock products despite the evidence that excess consumption undermines public health. For example, the US Department of Agriculture has been criticised for spending 550 million USD a year promoting the consumption of animal foods while America's obesity and diabetes rates are double, and cancer rates triple, those seen in other parts of the world.<sup>218</sup>

There are also large hidden costs associated with the provision of healthcare and remediation of environmental damage. Added together, the total costs to society is estimated to be 414 billion USD in the US – the equivalent of adding 1.70 USD in costs for each dollar of retail sales. If those costs were internalised in the price, a 3.5 USD gallon of milk, a 4.56 USD burger and a kilo of pork ribs would jump to 9, 12 and 32 USD respectively.<sup>219</sup>

### 5.2.2. *Animal-feed producers*

In contrast to a disperse livestock production, the processing of animal feed is increasingly concentrated in the hands of a few major agribusinesses.

Demand for animal feed continues to grow in line with meat consumption. The manufacturing of animal feed is dominated by a few agribusiness giants, such as CP Group (Charoen Pokphand), Cargill, New Hope and Purina, who buy grains and oilseeds from producers worldwide and sell them as animal feed for the livestock sector in the global market. The top 20 companies, which control 40% of the global market, are primarily based in Asia, followed by EU and the US.<sup>220</sup>

Market leader **CP Group** is a large Thai conglomerate of food-related companies. In 2017, CP produced 27.6 billion tonnes of feed for the poultry, pig, ruminant and pet feed markets in Thailand, China and Vietnam and reported 15 billion USD in total sales.<sup>221</sup> The second-largest producer of feed in 2017 was Chinese **New Hope Liuhe** (20 billion tonnes of fish, pig and poultry feed)<sup>222</sup> followed by US giant **Cargill** (18 billion tonnes of feed for the poultry, pig, ruminant, pet and horse feed markets).<sup>223</sup> Cargill, which is involved in a range of food, agricultural, financial and industrial interests, reported total sales of 115 billion USD – around the GDP of Hungary – in 2017.<sup>224</sup> Cargill operates hundreds of feed mills worldwide and owns several animal and pet feed brands, including Nutrena.<sup>225</sup>

### Responsible soy sourcing and moratoriums on deforestation

Due to the causality between increased soy production for animal feed and deforestation and ecosystem destruction in South America, there has been mounting pressure on consumer-facing brands and their feed suppliers to increase transparency across the supply chain and eliminate deforestation. The most famous and successful example of an environmental solution was the Soy Moratorium, which Brazil adopted in 2006 and through which companies committed to stop purchasing soy that came from deforested areas, was associated with slave labour or encroached on Indigenous Lands. The Soy Moratorium was signed by members of ABIOVE (Brazilian Vegetable Oil Industry Association) and ANEC (National Association of Cereal Exporters), which control 92% of soybean production in Brazil. It was renewed in 2008 with the participation of the Brazilian government, and in 2016 it was renewed indefinitely.<sup>226</sup>

As the majority of soy was produced for animal feed, traders and consumer-facing companies, such as McDonald's, played a key role in making it happen. The moratorium has been hailed a success. According to Greenpeace, since its inception to 2016 deforestation has fallen by 86% in the 76 municipalities covered by the moratorium, which produce 98% of the soybeans in the Amazon biome.<sup>227</sup>

The shortcoming of this commitment was that it only covers one ecosystem (the Amazon) and one country (Brazil). Deforestation has therefore moved into new countries (Paraguay and Argentina) and new areas (Cerrado). Recent reports have highlighted that the Cerrado (a savannah-like habitat) has lost more than 105,000km<sup>2</sup> of native cover since 2008 – 50% more deforestation than occurred during the same time period in the Amazon.<sup>228</sup> An investigation by Mighty Earth into the production of soy in Argentina and Paraguay for animal feed in Europe revealed that extensive destruction of natural ecosystems, including incidents of illegal deforestation, continues to take place. The report found significant connections between the areas investigated and Cargill and Bunge, despite the traders' commitments to responsible sourcing.<sup>229</sup>

Following increasing pressure about environmental destruction in the Cerrado, over 60 companies – including McDonald's, Unilever and Walmart – have signed the Cerrado Manifesto, in which they have agreed to support measures that would eliminate native vegetation loss in the Cerrado from their supply chains. But in contrast to the 2006 Amazon Soy Moratorium, the Cerrado Manifesto did not commit signatories to halt purchases of farm products from newly deforested areas. Separately, in June 2018 the Netherlands-based Louis Dreyfus Company became the first major commodity trader to pledge to stop buying soy from newly deforested land in the Cerrado. The company gave no timetable but said it would work to establish a 'realistic target date' to end deforestation in its Cerrado supply chain.<sup>230</sup>

### 5.2.3. *Processors of livestock products*

In line with trends in the animal-feed sector, meat processing is also increasingly concentrated, with some major business operations dominating an increasingly globalised market.

The world's leading meat producer is Brazilian family-owned **JBS**. It dominates the meat-processing industry in Brazil and has been expanding rapidly through mergers and acquisitions into other key markets, particularly the US, where more than half of its total revenue of 40.3 billion USD now comes from.<sup>231</sup> JBS is the world's largest beef, chicken, leather and tallow-derived biodiesel producer and the second-largest lamb and pork producer, and it owns some of the most recognisable meat brands in the world, such as Seara, Pilgrim's Pride, Moy Park and Doriana.<sup>232</sup>



Among the major US processors, **Tyson Foods** remains the market leader; in 2017, it reported sales figures of 38.2 USD billion and employed 117,000 people in the US alone.<sup>233</sup> **Cargill Meat Solutions** follows, with sales of 20 billion USD reported in 2017.<sup>234</sup>

In contrast, sales from European and Asian meat processors are much lower in value because they are more focused on lower-value meats, such as pork and chicken. The exception is the world's top pork processor, the Chinese **WH Group**, which reported sales of 22.3 billion USD in 2017, has acquired major operations in the US (**Smithfield and Clougherty Packing**) and Europe (**Pini**), and is looking for further beef and poultry assets globally.<sup>235</sup>

Large meat companies in the EU include **Danish Crown**,<sup>236</sup> **Tonnies**,<sup>237</sup> **Vion**<sup>238</sup> and **LDC**,<sup>239</sup> which reported respective annual sales figures of 8.3 billion, 6.9 billion, 5.1 billion and 3.8 billion EUR in 2017. Danish Crown, Europe's largest pork company - operating in Denmark, the UK, Sweden and Poland - has been reducing its slaughtering capacity due to falling demand. It is owned by a cooperative of Danish farmers. LDC is the largest poultry producer in the EU, operating in France, Spain and Poland.

In contrast to the meat sector, the top three global dairy companies in terms of value are European. In 2017, the reported dairy products turnover of **Nestlé** (the world's biggest food and drink company), **Lactalis and Danone** reached 21.4 billion, 17.7 billion and 15.5 billion EUR respectively. Non-European leading dairy companies include **Dairy Farmers of America** and New Zealand's **Fonterra**, with turnovers of 13 billion and 12.1 billion USD respectively in 2017, despite processing much larger milk volumes.<sup>240</sup>

Traceability in the supply chain remains poor, so it is mostly not possible for consumers to obtain comprehensive and accurate information on how their fresh and frozen meats have been produced. Nevertheless, consumers of meat products are increasingly demanding full traceability following a number of high-profile adulteration scandals, such as the substitution of horsemeat for beef in certain processed food products in Europe in 2013, and the adulteration of infant milk formula with melamine in China in 2008. The horsemeat scandal, in particular, shone a light on the length, complexity and global nature of beef supply chains. One consequence has been a trend for retailers and food-service providers to shorten their supply chains by establishing direct relationships with producers, rather than relying on an opaque chain of traders and wholesalers to supply products.<sup>241</sup>

Consumer-facing brand owners of further processed meat and dairy products - such as cured meats, sausages, cheese, yoghurt, ice cream, etc. - are under increasing pressure to address public concerns around the sustainability of their products. For example, efforts by certain animal-derived food products brands - under **Unilever** (Ben & Jerry's Ice Cream, Hellman's, Flora, Calve, etc.), **The Kraft Heinz Company** (Philadelphia, Cadbury's), **Premier Foods** (Mr Kipling), **Hain Frozen Foods** (Linda McCartney), **Nestlé** (Nestlé Group, Herta) and **Danone** (Danone Nutricia), among others - to source eggs and/or milk with lower environmental and welfare impacts have been recognised by leading NGO, Compassion in World Farming.<sup>242</sup>

## Carbon footprint: are meat and dairy companies the new Exxon?

Few meat and dairy companies calculate or publish their climate emissions, so little information is known about their individual carbon footprints. Unlike big emitters in other sectors, such gaps in the data have helped the big meat and dairy companies to avoid public scrutiny of the climate impacts of their operations.

A recent joint report from GRAIN and the Institute for Agriculture and Trade Policy (IATP), reviewing efforts undertaken by the world's 35 largest meat and dairy companies, concluded that only four companies - NH Foods (Japan), Nestlé (Switzerland), FrieslandCampina (the Netherlands) and Danone (France) - provide complete and credible emissions estimates. All other companies, including all major meat processors (e.g. JBS and Tyson), were found to either report incomplete or non-comparable datasets or, in the majority of cases, not to report at all.

Shockingly, the report estimates that the annual CO<sub>2</sub> emissions of the top 20 meat and dairy corporations (933MT) are higher than those from Germany (902MT) and Canada (722MT), and almost double those of Australia, the UK or France. In fact, the report found that the five meat and dairy corporations alone (JBS, Tyson, Cargill, Dairy Farmers of America and Fonterra) are together responsible for 587.3MT of CO<sub>2</sub> - a more than Exxon (577MT), Shell (508MT) and BP (448MT). The report also found that the top three corporations in this sector (JBS, Tyson and Cargill) have the weakest targets - or, in the case of JBS, no emission-reduction targets at all.

This study is the latest eye-opener on the urgency of addressing the climate impacts associated with the largest meat and dairy corporations. As the report points out, even if all other economic sectors achieve emission reductions to stay below 1.5°C temperature increases (in line with the Paris Agreement), the projected growth in the meat and dairy industry sector would result in livestock eating up 80% of the total carbon budget by 2050.

### 5.2.4. Food retailers and food-service providers

Food retailers and service providers are the largest buyers and suppliers of livestock products. They include multibillion-dollar companies (such as retailers **Walmart**, **Costco**, **Kroger**, **Carrefour**, **Sainsbury's**, **Delhaize**, **Tesco**, **M&S** and **Whole Foods**) and food-service providers (such as **McDonalds**, **Starbucks** and **Sodexo**).<sup>243</sup> **McDonald's**, for example, reports that its beef and dairy purchases represent 2% of global production.<sup>244</sup> Meanwhile, **Starbucks** reportedly uses 423 million litres of milk every year.<sup>245</sup>

Food retailers are often accused of exploiting their effective monopoly, as the biggest buyers of food, to provide customers with the lowest prices possible. Food retailers exercise tight controls over their specifications as to how food is produced, packaged, stored and delivered to them. They can do so because they often have direct contracts with selected farmers, and favoured slaughterhouses and processing and packing companies.<sup>246</sup> They also employ third parties to regularly audit suppliers to ensure they are meeting the retailer's standards.

As part of the supply chain closest to the consumer, food retailers and food-service providers face the greatest public pressure to 'come clean' on their operations. Sustainability plays an increasingly important element in their ability to gain and retain customers, often forcing them towards greater transparency and more ambitious commitments.

Over recent years, this has indirectly led to significant progress being made in improving the sustainability of egg production. This has been particularly successful in the UK, where major food-service operators (such as **McDonald's**, **Prêt A Manger**, **Subway**, **Starbucks**, **KFC**, **Burger King** and **IKEA**) and big supermarket chains (such as **M&S**, **Waitrose**, **Morrisons**, **The Co-op** and **Sainsbury's**) have stopped, or are planning to stop, serving or selling non-free-range eggs – either when whole or as an ingredient in a product.<sup>247</sup>

In addition, a number of major players (such as **McDonald's**, **Subway**, **KFC** and **Pizza Hut**) have moved towards reducing the use of antibiotics in poultry products, following recent revelations about the contribution of livestock farming to antibiotic resistance in humans.<sup>248,249,250</sup>

### Sustainability pledges and certification schemes: too little, too late?

Food retailers and service providers, as the most customer-facing organisations, are under growing pressure to guarantee the sustainability of their products. Given increasing awareness of the impacts of meat and dairy production, these organisations are starting to put pressure on their upstream supply chain, and various initiatives have been launched.

However, a majority of such pledges set neither clear nor ambitious actions or targets. For example, McDonald's has made commitments of 'no deforestation of high-carbon stock areas and forests by 2030' and has started to source some of its beef from sources certified as sustainable under the Global Roundtable for Sustainable Beef (GRSB) in Canada and Brazil.<sup>251</sup>

In reality, McDonald's has been a leading partner in the establishment of the GRSB initiative, which aims to bring major companies (such as JBS, Cargill and Delhaize), farmers' associations and some NGOs (such as WWF) together to agree criteria that can be used for the certification of 'sustainable' beef production. So far, the principles agreed by the GRSB have been deemed 'deeply flawed' by a coalition of 50 environmental, consumer, public health, justice and animal welfare in the US, including major NGOs Friends of the Earth and the Sierra Club. These organisations are concerned that the agreed criteria 'open the door to greenwashing' of conventional beef production by failing to include major sustainable issues or to set a robust performance-measuring framework.<sup>252</sup>

Furthermore, a recent Changing Markets report, *The False Promise of Certification*,<sup>253</sup> evaluated several palm oil, fisheries and textile schemes to draw conclusions for certification in general. We concluded that most voluntary sustainability initiatives are inadequate – and can even present a barrier towards greater sustainability, by providing a cover for irresponsible corporate behaviour. The report recommended significant reform of the certification sector as well as other actions, such as government regulations and greater supply-chain transparency. In light of these findings, we seriously question the potential of the GRSB to drive the move towards greater sustainability in the sector, and further emphasise the need for government action to drive reductions in the sector's ecological degradation.

### 5.2.5. The market for organic and more sustainably produced meat and animal products

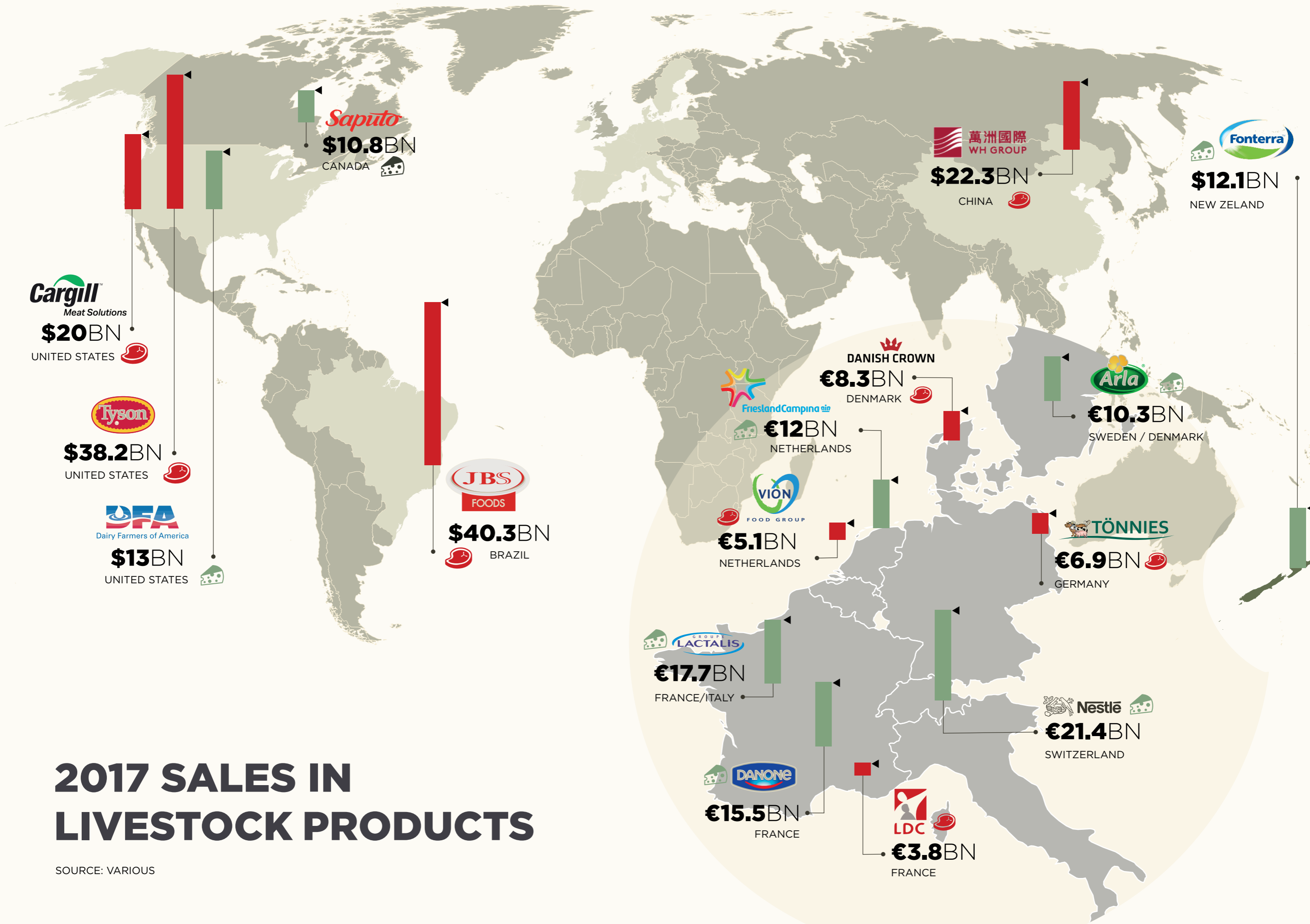
As seen in the previous chapters, there is a consensus across the scientific community that significant reduction in meat and dairy consumption is needed to avoid dangerous climate change. However, the public debate often revolves around the argument that, instead of going vegan or vegetarian, consumers should switch to better-produced meat and animal products such as organic, pasture-fed or free-range.<sup>254</sup> Such production methods are better from environmental and animal welfare perspectives, but have often been criticised by the proponents of status quo as requiring too much land. This section looks at what better meat production could look like, but with the caveat that better production should be undertaken in parallel with a reduction of consumption – especially in the Global North, where consumption levels are excessively high – and a shift towards healthier diets.

The UK alliance *Eating Better* recently released a report outlining a number of criteria that policymakers, producers and the public should consider when following a better meat and dairy approach. These include lower climate impacts; better welfare; sourcing natural and local feed; lower consumption of animal products and increased consumption of plant-based alternatives in the diet; lower antibiotic use, cutting waste and buying from smaller and local suppliers.<sup>255</sup>

Although no certification scheme considers all these elements, the report stressed that organic certification comes the closest. Organic certification is indeed the best-known sustainable production scheme for better meat. Its primary focus is to minimise the environmental impacts associated with livestock production and restrict the use of chemical inputs (fertilisers, antibiotics, etc.). However, organic certification mostly does not address GHG emissions, and some animal welfare organisations have criticised it for still allowing many bad practices, such as castration, transportation of animals, etc.<sup>256</sup> Proponents of intensive meat production have also criticised organic certification for its higher land requirements, although such critical voices normally do not recognise the need to deliver significant reduction in livestock numbers alongside organic production.

In any event, organic livestock production currently represents a very small share of the total worldwide market. It is estimated, for instance, that around 2.7% of all UK livestock production is organic.<sup>257</sup> This is higher than both US and EU averages,<sup>258,259</sup> but comparisons are difficult because certification standards differ across regions. Organic livestock production outside the OECD remains very limited, although there is some organic dairy (Egypt, Saudi Arabia, United Arab Emirates, Brazil and India) and beef (Brazil, Argentina and parts of Africa) production.<sup>260</sup>

An emerging movement in this area relates to livestock production reared under 'permaculture' conditions, which resemble traditional production systems (such as silvopastoral). Permaculture not only builds on the sustainable aspects of production captured under organic certification but also seeks to go further, aiming to produce livestock in a closed local loop, within which all inputs and outputs are provided and accommodated (animals are fed on local resources, animal waste is used locally to fertilise animal farming, etc.).<sup>261</sup> Similarly, biodynamic is a closed-loop method of predominantly mixed farming (livestock, arable and horticulture) in which the farm is a self-sustaining organism, requiring far fewer external inputs. In practice, this means a commitment to crop rotation and composting, little or no tillage or application of chemicals, and employment of a system of water capture and reuse.



# 2017 SALES IN LIVESTOCK PRODUCTS

SOURCE: VARIOUS

Interestingly, research from the University of Cambridge has shown that the adoption of silvopastoral systems by livestock farmers can lead to benefits in terms of increased biodiversity and improved animal welfare. The paper claims that using a diverse group of edible plants in a silvopastoral landscape promotes healthy soil with better water retention (and less runoff); encourages predators of harmful animals; reduces GHG emissions; reduces injury and stress in animals, improves welfare and encourages biodiversity by using native shrubs and trees.<sup>262</sup>

Additionally, the paper claims that such systems can provide better working conditions for farmers and increase profits. Shrubs and trees with edible leaves and shoots, along with pasture plants, produce more food for animals per unit area of land than pasture plants alone. Trees and shrubs have the added benefit of providing shade from hot sun and shelter from rain. In certain cases, where such systems have been adopted and ruminants (such as cows, goats and sheep) have consumed plants from a silvopastoral system, researchers have seen significant increases in growth and milk production per hectare.<sup>263</sup>

## 6. The rise of meat alternatives

*Once seen as a radical lifestyle choice, vegan, vegetarian and 'flexitarian' diets have reached a cultural tipping point and are now going mainstream. Popular celebrities, entrepreneurs, politicians, athletes, famous chefs and royals are promoting a switch to plant-based diets as a way to improve health and fight climate change and deforestation. This growth in demand has led many food companies to increase their offer of traditional plant-based proteins, and has resulted in the rise of new start-ups using the disruptive power of modern computing, food technology and biotechnology to create highly innovative alternatives to meat and other animal products. This chapter looks at this emerging trend, explores how different incumbents have responded to it - ranging from attempting to hinder the expansion of meat- and animal-product alternatives to investing in them - and discusses the challenges and opportunities this poses.*

### 6.1. A short history of meat alternatives

Despite being perceived as a new concept and trend, meat-free diets have been practised for thousands of years, by many cultures across the world, for a variety of moral, religious or economic reasons. Some notable examples include religious groups in Babylon and Ancient Egypt, who abstained from flesh and the wearing of animal clothing based on karmic beliefs in reincarnation, and thinkers in classical Greece, such as Pythagoras, who promoted meat-free diets to avoid animal cruelty and encourage better health.

Moreover, abstention from meat is a concept embedded in many Eastern religions; as such, vegetarian diets remain common practice in many parts of Asia.<sup>264</sup> For example, 23–37% of India's 1.3 billion population is estimated to be vegetarian.<sup>265</sup> It is therefore not surprising that the first meat alternatives (made from tofu and wheat gluten, similar to seitan) were produced earlier than 0 AD in China.<sup>266</sup> Other Asian traditional products include tempeh and yuba (soy-derived) and various nut-based products.

In the West, 19<sup>th</sup>-century fundamentalist Christian groups were particularly important in the promotion of vegetarian diets. These groups preached against animal slaughter - preaching that some groups on the fringe of Christianity in the Middle Ages had also undertaken. Among their followers were the Bible

Christian Church in England and Seventh Day Adventists in the US, and their discourse influenced the foundation of the Vegetarian Society in England and the US in the 19<sup>th</sup> century.<sup>267</sup>

The preaching of Seventh Day Adventists in the late 19<sup>th</sup> century is also associated with the origin of modern meat alternatives. Dr John H. Kellogg, driven by his Adventist beliefs, started experimenting with the development of plant-based products to encourage people to shift to vegetarian diets. It is through this process that him and his brother, Will, accidentally developed the basic recipe for today's breakfast cereals (based on flaked boiled wheat) while trying to provide products for patients at the Battle Creek Sanitarium.<sup>268</sup> While the popularity of the breakfast cereals led Will to focus on the foundation of **Battle Creek Toasted Corn Flake Company**, the origin of today's **Kellogg's**,<sup>269</sup> John created the **Battle Creek Food Company** focusing almost entirely on the production of meat alternatives. This company was best known for a nutmeat product called Protose, which combined wheat gluten, peanuts and soy to form one of the first well-known commercial meat alternatives of the modern era.

Inspired by Kellogg's products, others followed suit in the creation of meat alternatives. These included other Adventist-led companies, such as **Madison Foods**, **Loma Linda Foods**, **Dr Harry Miller's International Nutrition Laboratory** and **Special Foods**. The latter, founded by Dr George Harding, started by supplying a range of nutmeat products similar to Kellogg's Nutose in 1939; he then developed a vegetarian soy burger (Choplet Burger) in 1945 and vegetarian hotdogs (Meatless Wieners) in 1949, both of which were a commercial success.

Another company, **Worthington Foods**, illustrates well how technology innovations in this field have led to rapid commercial success. Their big breakthrough came in the 1950s-1960s, when they applied technology to spin soy into fibres (initially developed for industrial applications) to a food context. The resulting products couldn't be canned, so Worthington had to make a bold move towards supplying them frozen. These changes set the foundation of a new generation of meat alternatives from vegetable protein, more closely resembling the texture of meat, which were the first of their kind to enter the mainstream food retail market in the 1970s under the **Morningstar Farm** brand and remained a market leader for years to come.<sup>270</sup>

Another of the most well-known meat-free brands, **Quorn**, didn't enter the market until 1980s. This product, a dough-like mycoprotein fermented from a fungus found in soil called *Fusarium venenatum*, has its origins in yeast research conducted by petroleum and chemical companies in the 1960s. Quorn is sold in ready-to-cook forms resembling cubes and mincemeat, and is an ingredient in a range of vegetarian meals like burgers, sausages, pizzas, lasagne, etc. Quorn, now owned by Philippine giant **Monde Nissin**, has sales over 200 million GBP worldwide and expects to reach 1 billion GBP towards the end of 2020s.<sup>271</sup>

Following Quorn's success, in recent years there has been another major innovation in food technology. Originating from research in the 1990s, high-moisture cooking extrusion processes have enabled, in one step, the texturing of plant-based proteins into fibrous structures that mimic muscle-meat-like structures, giving them a bite and mouth-feel closer to meat.<sup>272</sup> Perhaps the leading commercial example of this is the company **Beyond Meat**, whose products are famously said to have fooled the taste buds of Microsoft founder Bill Gates and others, leading to their investment in the company.<sup>273</sup> Today, Beyond Meat is growing apace; sales doubled in 2017, and they have a new factory to satisfy current sales' expansion into 50 new countries.<sup>274</sup>

Today can be considered an entirely new chapter in the history of meat-alternative innovations - an inflection point at which change is accelerating faster than ever before. What's different now is that innovation in meat alternatives is increasingly driven by the power of cutting-edge computing and

biotechnology fused with the science of applied food technology.<sup>275</sup> And, as with many other technologies and industries (notably energy and renewables), the increase in new products' quality and the speed at which their prices will fall could be very rapid, coming as a surprise to many - not least incumbent companies stuck in old business models.

For this reason, and following a shift in consumer demand, investments from a diverse range of sources are now pouring into the development and marketing of meat alternatives around the world. On the one hand are many venture capital firms and high-net-worth individuals; on the other, established consumer goods and meat industry companies. Whatever their individual motives, they all have in common an expectation of making huge profits (or losses) from the disruption of one of the world's biggest industries.<sup>276</sup>

The story of meat alternatives doesn't stop here - indeed, this is where the really interesting bit starts. The new wave of meat- and animal-product-alternative companies is driven by modern computing (e.g. machine learning) and biotechnology (cell culture, CRISPR), which have been the driving forces behind disrupting industry after industry because they bring exponential change. Crucially, the costs of technology-driven products decrease over time, often very rapidly and faster than expected, as seen in solar energy. This is likely to be the case for many meat-alternative products as well. The cost of a burger made with cultured meat has fallen from 250,000 USD five years ago to around 10 USD today.<sup>277</sup> This gives meat alternatives the potential to outcompete on price and revolutionise markets.

## 6.2. Plant-based diets enter the mainstream

Fast-growing awareness about the negative impacts associated with our excessive meat consumption patterns on the environment, animal welfare and our health is increasingly shifting people towards plant-based diets and meat-free products. Such trends are also being seen in the workplace, where an increasing number of big corporate companies are promoting, or at least supporting, plant-based eating.<sup>278</sup>

Today, the number of vegans and vegetarians is growing rapidly, and is estimated to be approaching 5% of the population in many Western countries.<sup>279,280</sup> One example is a 2016 poll in the UK, from The Vegan Society, which reported that 3.25% of the population (1.68 million people) are either vegetarian (1.14 million) or vegan (0.54 million - up 300% in the last decade).<sup>281</sup>

Alongside the increase of people who follow vegan or vegetarian diets is a parallel trend towards *flexitarianism* or *reductionism* ('consumers choosing to significantly reduce their intake of animal products'), which is believed to be behind the largest portion of the increase in sales of plant-based products. This is illustrated by a recent study that suggests over 40% of British people are cutting down on their meat intake, and that 35% of Americans get most of their protein from sources other than meat.<sup>282,283</sup> In France, 34% of households in 2018 (up from 25% in 2015) are trying to reduce or limit their consumption of animal protein.<sup>284</sup>

Most importantly, this shift towards cutting down on meat consumption is being led by the millennial generation (those born at the end of the 20<sup>th</sup> century), with following generations showing an even greater shift,<sup>285</sup> indicating that future consumers will increasingly be demanding meat alternatives. In the UK, for example, 41% of all vegans are aged 15-34, compared to just 14% who are over 65. Market researchers see this as part of a broader trend among young people towards healthier lifestyles, including lower alcohol and tobacco consumption, resulting in them being dubbed 'Generation Moderation'.<sup>286</sup>

## Plant-based diets and popular culture

The rise of vegetarianism, and especially veganism, has been significantly driven by popular culture and famous personalities who have embraced plant-based diets and are encouraging others to change their dietary habits, often in their own personal capacity or as ambassadors for different environmental or animal rights organisations. Increasingly, eating less or no meat is becoming normalised and mainstreamed in the way it is represented on television and in films. Campaigns such as Meat Free Mondays or Veganuary, documentaries and particularly (social) media are also playing an instrumental role in raising awareness and driving behavioural change, as more people learn about the scale of negative impacts and widespread unethical practices associated with the majority of meat and dairy production methods.<sup>287</sup>

### Cowspiracy

Cowspiracy is a 2014 documentary film directed by Californians Kip Anderson and Keegan Kuhn that investigated the impact of animal agriculture on the environment and portrayed environmental organisations as being scared to campaign on the issue. The controversial film – which has gained distribution on Netflix and, as a result, been widely watched – gives shocking statistics about the impacts of meat consumption on the planet through the personal narrative of one of its directors, while denouncing the power of



the industrialised farm lobby and accusing environmental NGOs of inaction and complicity.

The film-makers have received significant criticism from scientists and environmental organisations for unnecessarily exaggerating some of the facts in the film to better fit its predetermined narrative. For example, the film claims that 51% of global GHGs are caused by the livestock industry; this is based on a discredited, non-peer-reviewed article, as opposed to the 16.5% calculated by the world's leading authority on agricultural GHG emissions, the UNFAO.<sup>288</sup>

Still, if judged by global audience gained and levels of awareness of livestock as a leading environmental issue (especially among younger audiences), the cultural impact of this low-budget film is very substantial; it has inspired numerous individuals to cut meat out of their diets and pushed many NGOs to take the issue more seriously in their communications and campaigns. In the words of one blogger, 'all over the internet, there are stories of teenagers forcing their parents to watch it, and of whole families turning vegan, or at least vegetarian, as a result'.<sup>289</sup>

Several years on from the *Cowspiracy* 'phenomena', the film represents but one of many documentaries, widely available online through a range of streaming services, that highlight the health and environmental impacts of excessive meat consumption and animal suffering associated with industrial livestock production. Civil society action and campaigns on the issue of meat consumption are today widespread, as are videos, animations and other social media content. And, in a sign of the issue's current status as a more mainstream topic of discussion, coverage on television, radio and other media formats takes place where once it was taboo.

## Famous vegans and vegetarians<sup>290</sup>

Celebrity vegans and vegetarians have given up meat for different reasons, ranging from health and good looks to environmental convictions or animal welfare. Many are ambassadors of People for the Ethical Treatment of Animals (PETA) and other environmental or animal rights organisations, and they come from all ranges of public life, from politics to the film and music industries. Famous vegans are often very outspoken and can have a lot of influence over news coverage and the public directly via social media – especially over young people, who are digital natives. Some of them, like Moby, are also opening vegan restaurants and cafes; others, such as Linda McCartney, have started whole-food vegetarian and vegan brands or are investing in promising new producers of meat alternatives.



The ever-growing list includes actors and directors (Joaquin Phoenix, Brad Pitt, Alec Baldwin, Woody Harrelson, Natalie Portman, Pamela Anderson, Demi Moore, Michelle Pfeifer, Alicia Silverstone, James Cameron, Casey Affleck, Jared Leto, Liam Hemsworth, Jessica Chastain, Johnny Depp, etc.); musicians (Bryan Adams, Moby, Thom Yorke, Alanis Morissette, Stevie Wonder, Miley Cyrus, Ariana Grande, Jennifer Lopez, Leona Lewis, Paul McCartney, etc.); TV stars (Ellen DeGeneres, Russell Brand, etc.); sportsmen (Mike Tyson, Martina Navratilova, Venus Williams, Carl Lewis, etc.), politicians (Bill Clinton, Al Gore, Jeremy Corbyn, etc.) and royals (such as Spanish Queen Emerita Sofia).

Particularly interesting and influential are the growing number of celebrity chefs and other food-industry taste-makers driving cultural change in how mainstream audiences perceive vegetarian and vegan food – whether through adopting and advocating for meat-free diets themselves or by cooking or providing plant-based options in their restaurants, recipe books or TV shows.

### 6.3. Sales of meat replacements are growing

A number of drivers have been associated with the recent rise in consumers' interest in plant-based foods. These include negative perceptions of traditional animal-based products as unhealthy, as well as concerns around animal welfare and the sustainability of livestock production. In addition, positive qualities of plant-based products that attract consumers include that they tend to be more convenient, easier to prepare and more adjustable to personalised nutrition trends, as well as consumers' general curiosity about relatively novel products.<sup>291</sup>

The global market for meat substitutes stands at an estimated 4.6 billion USD. Meat substitute products based on soy, tofu, textured vegetable protein and mycoprotein accounted for the largest market share in 2017.<sup>292</sup> The US was the largest national market for meat substitutes in 2016 (700 million USD), followed by the UK (~400 million USD) and Germany (~300 million USD).<sup>293</sup> Further growth is predicted, reaching 5.2 billion USD in 2020.<sup>294</sup>

The market for plant-based meats remains well below 1% of that of the global meat market.<sup>295</sup> However, while the growth of the meat market is stagnant in the majority of high-income countries,<sup>296</sup> the market for meat alternatives is experiencing huge growth and is one of the fastest-growing food categories. Meat alternatives are growing at annual rates of over 20% in Denmark; 15% in Germany; 10% in Argentina and Australia; 5-10% in Sweden, the UK and the Netherlands; and just under 5% in US Israel and Canada.<sup>297</sup> Overall, it is expected to grow by 6.8% to over 6.4 billion USD by 2023.<sup>298</sup>

According to some market analysts, the growing trend towards plant-based meat alternatives is such that they are on the cusp of breaking into the mainstream – analogous to the time when non-dairy milk alternatives began to grab market share following their championing by big food-industry players, such as **Dean Foods**. Indeed, the market for non-dairy products (like soy and almond milks) has grown to make up 10% share of the overall market, with total sales doubling between 2009 and 2015 to 21 billion USD.<sup>299,300</sup> The most popular dairy-alternative products are those derived from soy and the largest market is the Asia-Pacific region, led by China, due to increasing demand for lactose-free food products coupled with an abundance of soy-based alternatives.<sup>301</sup> The market is expected to continue to grow to reach 34 billion USD by 2024.<sup>302</sup>

In contrast to trends for meat and dairy substitutes, consumption of pulses per capita has experienced a slow decline in both high- and low-middle-income countries to an average of 7kg per year, although very large variations remain at country level.<sup>303</sup> Total pulse production stands at 78MT, and India, Canada and Myanmar are the largest pulse producers.<sup>304</sup>

#### Should we just switch from livestock to fish?

One option to address health and climate issues related to excessive consumption of meat is to shift some of this consumption to fish, a healthy food type that is often under-consumed (relative to dietary recommendations) in many high-income countries, such as the UK.<sup>305</sup> However, doing so poses a number of challenges from the perspective of environmental sustainability and animal suffering.<sup>306</sup> In the UK, for example, all domestic fish landings plus imports still fall 64% below the recommended level of intake.<sup>307</sup> Raising consumption could therefore increase pressure on British stocks or on those abroad.

Even at current levels of global consumption, a large number of global fisheries are in a state of crisis and ongoing decline.<sup>308</sup> World per-capita fish consumption has grown steadily, exceeding the record figure of 20kg per year in 2016; this is mostly driven by growth in aquaculture, which now provides more than half of all fish destined for human consumption. Most marine stocks continue to be reported as either over- (31%) or fully fished (59%); only 10% are classified as under-fished.<sup>309</sup> While aquaculture can help alleviate the pressure on wild fisheries from growing global demand for fish, its dependence on external feed inputs, and in particular fishmeal and oil, still places a growing burden on ocean resources.<sup>310</sup>

A large-scale switch from meat to fish consumption is therefore likely to make achieving sustainable fisheries even harder, and so is not a viable solution.

### 6.4. The meat industry's reaction to growing competition

Different parts of the powerful meat and dairy industries are reacting in different ways to consumption rates declining or remaining stagnant in most high-income countries, and to health and environmental organisations increasingly challenging their operational models and marketing. These reactions vary – from attempts to hinder the expansion of meat and dairy alternatives to hedging against disruption by directly investing in them.

#### 6.4.1. 'Make Meat and Dairy Great Again!': farming interests strike back

Many powerful meat and dairy interests are feeling increasingly under attack from civil society groups and new food business players that market their plant-based products as more ethical and sustainable sources of protein. In response, industry groups are turning to their well-established lobbying arms and political networks for support.

Historically, lobbying activities for the livestock industry have focused on maintaining – and even increasing – significant public subsidies to support farming operations, which have led to overproduction and encouraged an excessive level of consumption of animal products. At the same time, their successful weakening (or blocking the introduction) of effective environmental regulation, which would control the environmental externalities of livestock production, has contributed to excessive production levels and disadvantaged more sustainable farming practices. On the demand side of the food system, lobbying efforts have been broadly effective in curtailing legislation designed to promote healthier diets with a greater share of fruit and vegetables.

The political power this demonstrates is just one reason why, despite growing public awareness of negative impacts associated with excessive meat and dairy consumption, policymakers continue to lack an appetite for policies and legislation in this area. A recent case in point is a European political strategy for a sustainable food system, '*Building a Sustainable European Food System*', which contained mild references to the need to address negative impacts of animal products and reduce consumption. The case was pulled from publication at the last moment – despite the European Commissioner for the Environment having already been announced its publication, and despite subsequent calls by civil society, academics, progressive businesses and over 60 cross-party Members of European Parliament for its publication.<sup>311,312,313,314</sup>

In response to the rise of meat and dairy alternatives and the perceivedly threatening market share they represent, livestock industry groups in multiple countries have begun calling for legal restrictions on the labelling of plant-based meat and dairy alternatives, so that terms such as 'milk', 'cheese', 'meat', and 'sausage' can only be used for products of animal origin. The rationale for this restriction is that it is necessary to protect consumers from being misled.<sup>315</sup> The companies behind plant-based alternatives and their advocates have denounced this move as purely motivated by economic concerns; they argue for the continued use of such terms, on the basis that consumers are smart enough to differentiate between products, and that the terms convey important information on what consumers can expect from them while clearly communicating their vegetarian or vegan characteristics.<sup>316</sup>

To date, these lobbying efforts to restrict product names have been most successful in Europe, where existing legislation defining milk products is being used to impose restrictions on the use of terms such as 'milk', 'butter', etc. on plant-based products, following a ruling by the European Court of Justice in 2017.<sup>317</sup> Industry groups and politicians are calling for similar restrictions on meat alternatives.<sup>318</sup> Although the European Commission has shown little appetite to act (for now),<sup>319</sup> France recently introduced legal restrictions, so plant-based manufacturers could face fines of up to 300,000 EUR for using terms such as 'sausage' and 'steak' in the labelling of their products.<sup>320</sup>

In the US, plant-based dairy producers have been asking the Food and Drug Administration (FDA) for years to confirm that they can use terms such as 'milk' in plant-based products but, to date, the FDA has not acted. In the meantime, this legal vacuum has encouraged a number of lawsuits against plant-based companies, and continues to create uncertainty among manufacturers and companies seeking innovative ways to develop, label and market new plant-based products.<sup>321</sup>

A draft legislative bill, the Dairy Pride Act, is currently stuck in Congress; but if it was to pass, it would specifically ban the use of terms such as 'milk' and 'dairy' for plant-based products.<sup>322</sup> The US Cattlemen's Association has filed a petition to the US Department of Agriculture to produce an official definition of 'beef' and 'meat' that excludes plant-based products.<sup>323</sup> All in all, these actions clearly show how nervous many meat and dairy industry corporations now feel about the threat posed by their plant-based competitors.

### Trick or tweet?

A further sign of industry intolerance towards policy support for low- or meat-free diets is a row over a single tweet between the UK meat industry and the Food Standards Agency (FSA) in August 2016, when the latter put out a tweet endorsing Meat Free Week.<sup>324</sup>

The industry's response was anything but proportionate. It reacted to the tweet as though it were an existential threat – engaging in a public row with the FSA on social media; issuing a joint statement between the NFU, National Sheep Association, Association of Independent Meat Suppliers, British Meat Processors Association, British Poultry Council and the National Federation of Meat & Food Traders;<sup>325</sup> and sending a joint letter to the Prime Minister, Theresa May, to complain about the FSA's actions and the need to 'restore the agency's impartiality'.<sup>326</sup> Finally, the FSA deleted the tweet.



### 6.4.2. Diversifying the risk

In contrast to this hostile lobbying approach (particularly adopted by industry groups directly representing livestock farmers), some international meat processors and marketers, consumer goods companies and food retailers have taken a different approach of seemingly embracing (or hedging against) the potentially market-disrupting opportunities of new plant- and cell-based alternatives to tradition meat products.

Examples in this category include companies that are developing their own brands of plant-based protein products (e.g. **Green Street** by Tyson; **Wicked Kitchen** by Tesco; Prêt à Manger's veggie-only stores),<sup>327</sup> those entering distribution deals with plant-based brands (e.g. Dean Foods supports distribution of **Good Karma Foods**),<sup>328</sup> or those buying up smaller plant-based protein companies. In the latter category, the rate and scale of mergers has started to accelerate in recent years (Table 1), with the number of acquisitions in the plant-based sector quadrupling in 2017.<sup>329</sup>

**Table 1: Major acquisitions of plant-based brands**

Year	Company	Industry sector	Acquired	Amount
2017	Maple Leaf	Meat producer	Lightlife	140 million USD
2017	Maple Leaf	Meat producer	Field Roast	120 million USD
2017	Nestlé	Food manufacturer/ dairy processor	Sweet Earth	Undisclosed
2017	Otsaka Pharmaceuticals	Pharmaceuticals	Danya Foods	405 million CAN
2016	Danone	Food manufacturer/ dairy processor	White Wave Foods (major plant-based milks such as Alpro and Silk)	12.5 billion USD
2015	Monde Nissin	Food manufacturer	Quorn	550 million GBP
2014	Pinnacle Foods	Food manufacturer	Gardein	175 million CAN

Increasing product offer in line with consumer trends is a common strategy practised by consumer goods producers to maximise profits. According to *Ethical Corporation* magazine, when the sales growth of ethical products (or other alternative products) is so significant, the risk of being involved seems lower than the risk of *not* being involved. Typical ways for companies to diversify risk include launching new ethical products, acquiring or buying into ethical brands, and (more generally) product rebranding, ethical marketing and communication activities; examples of all these actions can be observed in the plant-based market.<sup>330</sup>



The fact that some of these players include some of the largest dairy and meat producers (and hence plant-based competitors), such as Danone and Tyson, has puzzled many and been received with mixed reactions.<sup>331</sup> On the positive end, the argument goes that more money available for distribution will help increase the production of plant-based alternatives, their reach and ultimately their consumer base to take them mainstream. For example, Bruce Friederich, CEO of the Good Food Institute (GFI), believes that *'Dean Foods buying White Wave was the precipitating factor that moved plant-based milk from the dusty nether-regions of the health food store into every Target, Walmart, Kroger, Safeway, and other grocery stores in the country'*, and expects big players' move into meat alternatives to have a similar impact.<sup>332</sup>

On the other side of the argument is the question of whether incumbent industry players can play the role of 'champions' of plant-based products, in line with the scientific targets requiring a significant reduction in the consumption of meat and animal products, when these are so critical to their profits and bottom lines. After all, around three-quarters of Danone's sales of 24.5 billion EUR are related to dairy products (i.e. fresh products, or specialised nutrition, using 8 billion litres of fresh milk each year). Similarly, most of Tyson's 38 billion USD sales in 2017 were related to very large numbers of processed livestock - approximately 1,820 million chickens, 22 million pigs and 6.7 million cows.<sup>333</sup> In addition, some consumers (especially vegans worried about animal welfare) have expressed concerns about indirectly funding animal suffering by buying products that support these parent companies.<sup>334</sup> In general, big companies buying into the ethical or alternative products market tend to offer these product ranges as just a small part of their portfolio, and use this as a justification for not implementing progressive policies across their entire product range - something that could have significant environmental and social benefits.

*Ethical Consumer* highlights a number of potential downsides associated with the loss of independent and critical voices from small ethical companies when these are taken over by multinationals.<sup>335</sup> Among these, the article cites concerns around big multinationals putting pressure on standards to water down their ambition in line with their wider economic interests (e.g. organic certification was under a lot of pressure in the US when it decided to reject any trace of GM ingredients); getting easy access to new ethical markets without having to address unethical issues associated with the core of their business; money from ethical consumers going to a multinational corporation that does not maintain similar values for the rest of the products it makes; and diluting the ethical message of the companies acquired.

A cautionary tale in this regard is the oil company **BP**, which, after an initial rebrand to become **Beyond Petroleum** (at the same time as broadening its investments to include renewables and energy efficiency), later dropped or disposed of nearly all this work to refocus on its core business of fossil fuels.<sup>336</sup>



## Pro-plant-based messaging diluted following Danone's takeover of Alpro

**Danone** hit the headlines in 2016 when it announced it had agreed to buy **WhiteWave** for the impressive sum of 12.5 billion USD.<sup>337</sup> WhiteWave, which was a subsidiary of **US Dean Foods** until 2013,<sup>338</sup> is the owner of many popular brands of plant-based and organic dairy products, including the two leading brands of plant-based milks in the US and Europe, **Silk** and **Alpro**.<sup>339</sup>

Not all WhiteWave customers welcomed the move. Smaller brands such as Alpro had its most loyal customers in ethically-minded groups, and many of its customers felt Danone's credentials no longer lived up to their expectations. In fact, Danone has been the subject of consumer boycott by animal welfare groups (as a major dairy processor) and breastfeeding advocates (because of unethical and aggressive marketing of infant formula across the world).<sup>340</sup>

How far can a company like Danone, which is heavily invested in traditional dairy markets, go in terms of promoting the much-needed transition to plant-based products? Danone says its acquisition of WhiteWave is part of its *'Alimentation Revolution'*,<sup>341</sup> which is driven by the company's desire to profit from emerging consumer interest in plant-based products, or *'accelerate our 2020 profitable growth journey by offering consumers a wider choice of better-for-you and great-tasting food and beverages for a broader range of consumption moments'*.<sup>342</sup> In fact, Danone's strategy does not refer to the urgent need to decrease the consumption of animal-based products, or even explicitly acknowledge environmental and animal welfare issues associated with livestock products; rather, it sees plant-based products as complementary, i.e. *'developing a world-leading dairy and plant-based portfolio'*.<sup>343</sup>

This messaging (regarding animal- and plant-based products being complementary) seems to have been adopted by Danone's pure plant-based brands following acquisition. One such example is Alpro, which on its website tells consumers *'it's not necessary to eliminate all animal products'* but *'eating smaller amounts of animal foods, and replacing them with more plant-based foods, can bring about major benefits to both our health and the planet'*.<sup>344</sup> This flexitarian messaging is also now embedded in the Silk brand (*#ProgressIsPerfection*), which talks about consumers not needing to *'go totally vegan, or even vegetarian. Burger lovers and bean lovers—we love 'em all!'* and: *'Silk can be a step in the right direction. Try delicious almond milk, cashew milk or soymilk instead of your usual dairy milk in cereal, blend up a tempting smoothie, or pack a delicious dairy-free yogurt alternative for lunch. Every sip or spoonful counts.'*<sup>345</sup>

This change in messaging led to a social media spat between Alpro and some of its traditional customers following a tweet promoting *'a healthy diet consisting of one third animal-based products'*.<sup>346</sup> For many, this was Top of Forman expected clash of consumer cultures and brand values following the merge, as its plant-based brands moved from its core of vegan consumers to the growing number of flexitarians in the early mass market. However, some have warned that the dilution of the brand's values that underpinned its original success could result in its core consumers, whose passion is driving the success of such products in the first place, abandoning them.<sup>347</sup>

There is also a question about how compatible such messaging is with Danone's own climate goals of delivering zero net carbon emissions by 2050.<sup>348</sup> A recent report from GRAIN/IATP<sup>349</sup> evaluated 35 top meat and dairy companies and their commitments to reach the Paris Agreement. Although Danone came out as the only company committed to *'zero net emissions'* by 2050 (a target consistent with that laid out in the Paris Agreement), the report questions the feasibility of such goals without the reduction of dairy production and consumption. Danone is currently expecting to deliver such goals through extraordinary reductions in emissions intensity, and investing in projects to offset carbon in the Global South, while significantly increasing its production (by as much as 70% to 2030). GRAIN also points out that Danone's target is entirely voluntary.

## 6.5. Cutting-edge plant-based start-ups: the new Californian gold rush?

In addition to the more established plant-based companies, new businesses focusing on the development of innovative alternatives to animal-based products are growing fast, with a cluster forming around the US West Coast. These companies are using modern computing, biotechnology, medicine and food technology sciences to produce two distinct types of meat alternatives.

The first, often termed 'plant-meat' by these companies, is a meat alternative produced via a proprietary process and with a range of plant-based ingredients that aims to closely mimic the texture, look, flavouring, nutritional and cooking properties of real meat. The second takes a different angle on the problem by trying to grow or construct meat and other animal products, using animal and bacterial cell cultures and fermentation processes. These latter products are often called 'clean meat' – a name specifically chosen by the nascent industry to communicate that its products avoid many negative impacts associated with livestock farming, including environmental pollution, use of antibiotics and foodborne pathogens.<sup>350</sup> A subsection of the second is animal products produced through fermentation processes via enzymes, which is very similar to the way beer is produced, and has been used especially for milk and eggs. According to a recent paper by the Adam Smith Institute, cultured meat could mean a cut in agricultural GHG emissions of 78–96% while using 99% less land.<sup>351</sup>

The application of these new technologies – supported by a wave of funding and new institutions, such as the GFI, established to support the growth of the nascent industry – is yielding an entirely new generation of alternatives to animal foods beyond anything that has come before, including meat, milk, cheese, yoghurts, eggs, seafood, gelatine, albumin and other non-food products, such as silk and leather. These products are often seen as having a higher disruptive potential than traditional meat replacements, given that they are often indistinguishable to the consumer.<sup>352</sup> Moreover, due to their technological basis, ongoing year-on-year improvements to the efficiency and quality of production are expected to lead to economies of scale, and to outcompete animal-derived products on the basis of cost in the near future.

Among the new brands attracting major media headlines are:

- **Beyond Meat**,<sup>353</sup> whose flagship product is the *Beyond Burger*, a 100% plant-based burger that 'bleeds' beetroot juice;
- **Impossible Foods**,<sup>354</sup> whose flagship product is the plant-based *Impossible Burger*;
- **Hampton Creek**,<sup>355</sup> whose flagship products include plant-based eggs such as *Just Mayo* (an egg-free mayo) and egg-free scramble; the company is also investing large amounts into clean chicken, namely cultured meat grown from chicken and turkey cells;
- **Memphis Meats**,<sup>356</sup> which developed the first cultured meatball and is now focusing on developing other ground-meat items, such as hot dogs, hamburgers and chicken nuggets;
- **Perfect Day Foods**,<sup>357</sup> which focuses on developing cultured milk and other dairy products through the fermentation process, where yeast produces milk proteins;
- **Clara Foods**, which produces egg whites through a similar yeast-based process.

These start-ups are also attracting significant investments from high-profile, high-net-worth personalities, including Bill Gates and Leonardo di Caprio; venture capitalist firms, such as **New Crop Capital** and **Stray Dog Capital**; and major companies, such as **General Mills** and **Virgin Group**.

## The meat-investment paradox: largest meat companies investing into meat alternatives

The 'meat paradox' is a term often used to refer to the mental process of 'disassociation' by which people avoid thinking about an animal's conscious ability to think, feel and suffer when they are consuming animal products.<sup>358</sup> A similar paradox seems to be emerging across investments in the plant-based sector; companies with major stakes in the livestock sector – such as **Tyson** (the largest US meat processor), **PHW Group** (EU's largest poultry producers) and **Cargill** (a leading agri-business company) – are investing significantly into some of the most promising plant-based and 'clean meat' start-up companies.<sup>359</sup>

But is it possible to lead the transition towards plant-based diets when a significant share of your business's profits depends on keeping up levels of consumption of the animal-based products they are trying to displace?

Tom Hayes, President and CEO of Tyson, acknowledges that their investment in meat alternatives may seem counterintuitive – even to people within the company.<sup>360</sup> Nevertheless, Hayes states that Tyson is in the business of supplying protein to consumers, whether it is from animals or plants, and so '*a protein strategy inclusive of alternative forms is intuitive for Tyson Foods*'. In its statement '*Why are we investing in alternative proteins?*', there is also a suggestion that diversification is a risk-management strategy for the company: '*No one knows exactly what the future of food will look like. That's why we're exploring new approaches*'. The need to diversify was also raised by CEO of the PHW Group, Peter Wesjohann, in a statement following a deal to distribute *Beyond Meat* in Germany: '*We consciously embrace this supposedly unusual partnership because we believe in growth through diversity*'.<sup>361</sup>

In fact, diversification as a risk-management tool is part of the answer. According to a recent report by the 5-trillion-USD alliance of sustainable investors, **Farm Animal Investment Risk & Return (FAIRR)**, growing consumer and stakeholder concerns about the negative impacts of animal production and consumption (climate change, environmental pollution, excessive use of antibiotics, unhealthy diets, etc.) and the fast sales growth currently being experienced by plant-based food products means that companies with a large dependency on animal agriculture are more at risk if they choose to ignore these trends than if they try to engage with them.<sup>362</sup>

FAIRR's report identified three strategies being that companies are using to broaden their alternative protein portfolio, including acquisitions, venture investments, and increased product development and R&D. Nevertheless, their assessment of 11 leading global retailers (**Tesco, M&S, Delhaize, Sainsbury's, Kroger, Walmart, Whole Foods, Ocado, Morrisons, The Co-operative Group** and **Costco**) and five food manufacturers (**Nestlé, Unilever, General Mills, Mondelez** and **Kraft Heinz**) showed that most companies did not have meaningful programmes to monitor and address GHG emissions associated with animal agriculture. In addition, most companies diversifying into plant-based protein were driven by changing consumer habits, rather than a strategy for decoupling growth from unsustainable practices. Among the assessed companies, the report named Nestlé and Tesco as the best-prepared companies for profiting from plant-based proteins going mainstream, and called Costco out for an inadequate response.<sup>363</sup>

According to GRAIN/IATP's research,<sup>364</sup> any scenario that brings global meat and dairy production emissions within 1.5°C pathways requires significant cuts in emissions by these companies. However, most of the top 35 meat and dairy companies do not even comprehensively report their emissions, and only six have comprehensive targets covering the full range of emissions associated with livestock production. Among these six, Nestlé and Danone have robust commitments to reduce their absolute emissions. However, these commitments, while to be commended, are only voluntary. GRAIN concludes that: '*without legal regulations backed by strong sanctions, and absent independent systems of monitoring and verification, little can be done to hold these companies to their word*'. This points to the fact that there is a major gap when it comes to managing the transition of the food industry towards science-based climate targets. All the commitments, investments and even reporting requirements lack a clear policy environment to underpin and drive change in line with the scale of reductions needed.

# OVERVIEW OF MANUFACTURERS OF ALTERNATIVE PRODUCTS

## CANADA AND THE UNITED STATES

FORA FOODS				
MODERN MEADOW				
NUMU				
OCEAN HUGGER FOODS				
GOOD CATCH (AKA SEACO)		(M)		
ALPHA FOODS				
BLUE NALU				
BOLT THREADS				
CLARA FOODS		(★)		
FINLESS FOODS				
GELTOR				
MIYOKO'S KITCHEN				
NEW WAVE FOODS				
RIPPLE FOODS		(★)		
PERFECT DAY		(M)		
BEYOND MEAT		(M) (F) (★) (NGO)		
IMPOSSIBLE FOODS			(★) (NGO)	
JUST (INC) (AKA HAMPTON CREEK)				(★)
KITE HILL (AKA LYRICAL FOODS)			(F)	
MEMPHIS MEATS			(M) (★)	
SWEET EARTH			(D)	



DAIYA FOODS		(+)	
GARDEIN		(F)	
GOOD SEED			
ATLANTIC NATURAL FOODS			
NO EVIL FOODS			
NUTPODS			
SEATTLE FOOD TECHNOLOGIES			
FIELD ROAST			(M)
LIGHTLIFE			(M)
NUTRIATI			(F)
SILK			(D)

## EUROPE



QUORN		(F)	
LINDA MCCARTNEY			(F)
MEATABLE			
MOSA MEAT		(★) (M)	
OATLY			
ALPRO		(D)	

## ASIA AND OCEANIA



SUNFED MEATS		
INTERGRICULTURE		
GOOD DOT		

## ISRAEL



ALEPH FARMS		
MEAT THE FUTURE		
YOFIX		(F)
FUTURE MEAT TECHNOLOGIES		(M)
SUPER MEAT		(M)

## LEGEND

### PRODUCTS REPLACING

MEAT		SEAFOOD	
DAIRY		FASHION FIBRES (ANIMAL ORIGIN)	
FOOD INGREDIENTS (ANIMAL ORIGIN)		LEATHER	
EGGS		VARIOUS	

### OWNED OR RECEIVING INVESTMENTS FROM

CELEBRITIES / FAMOUS INVESTORS	(★)	FOOD MANUFACTURERS	(F)
DAIRY PROCESSORS	(D)	PHARMACEUTICAL COMPANIES	(+)
MEAT PROCESSORS	(M)	NGOs	(NGO)

Maps included in this infographic are for illustration purposes only and not up to scale. Although we have made every effort to present a comprehensive global picture of companies producing and investing in alternative meat products, this is a fast developing area, where data gaps might exist.

Source: Crunchbase & various

This chapter has shown the very different reactions of meat companies and investors to the growing market trends of meat alternatives. Such reactions seem quite similar to those of fossil fuel companies when confronted with low-carbon technologies such as renewables or electric cars. Interestingly, in this case, the low-carbon transition in food is largely driven by consumers, investors and some food companies – but it almost completely lacks the public policies that would support these trends and address the urgency of the challenge, as we will show in the next chapter.

## 7. Towards a low-carbon transition in the food system

*Increasingly, scientists, civil society organisations and enlightened consumers are converging on the realisation that excessive production and consumption of animal products must be reduced – for the simple reason that, if we are to achieve climate goals and SDGs, halt biodiversity loss and ensure food security in a future world of 9 billion people, doing so is inevitable. In many high-income countries, progressive consumers, civil society organisations and mission-driven businesses are catalysing this change, driving an ongoing trend towards lower consumption of animal products, an explosion of food innovation and a boom in the sales of plant-based products. While this is all good news, there is too much at stake, and the scale and pace of the transformation needed is too great, to be left to the market alone. Despite large year-on-year growth, in recent years the absolute market share of vegan and vegetarian food is still tiny compared to the meat and dairy sectors. If the transition to a low-emissions food system is to be a success, meat and dairy alternatives must go from niche to mainstream quickly. Governments need to take on this challenge and align policies that drive low-carbon transition in the food sector. As has been true for renewable energy and transport, the driving force for a transition to a low-emissions food system must come from a robust policy framework, the targets and incentives of which must align with what science says is necessary. This chapter looks at ongoing low-carbon transitions in the energy and transport sectors, and attempts to draw lessons from them to inform future actions to accelerate a transition to a low-carbon food system.*

## 7.1. The theory behind low-carbon transitions

Tackling climate change requires a fast and deep transformation across all major sectors of the economy, including electricity, transport, heat, industrial activities, forestry and agriculture. Although recent technical developments have delivered major cost reductions in key areas, such as renewable energy and energy efficiency, the rate of progress towards wider goals of deep decarbonisation remains too slow to reach the reductions needed to achieve the Paris Agreement's goals.<sup>365</sup>

While much of the research undertaken to inform such transitions seems to focus on available technologies and their expected economic costs, some academics argue that much more emphasis needs to be placed on understanding the sociotechnical and sociopolitical issues that either drive or inhibit the development, roll-out and scaling-up of new technologies, business models and other modes of human organisation. This includes the influence of issues such as innovation processes, business strategies, social acceptance, cultural discourses and political struggles.<sup>366</sup>

Historical research on transitions has often focused on explaining how and why large-scale change in societies, technologies and economies once took place. But today, rather than looking backwards, some of the most pressing questions for researchers are about how future societies and economies can transition – and so come into alignment with collective goals such as climate targets – as well as how, through action today, large-scale changes can be induced and guided towards these desirable end goals. This shared focus broadly delineates a multidisciplinary research field known as *sustainable transitions research*.

One of the core findings of this field is that large-scale changes in society, technologies and economies are deeply interconnected, complex and hard to predict and manage. co-evolving over time analogously to the evolutionary processes within ecosystems. Despite this inherent complexity, research into sustainable transitions has been able to develop a framework for thinking about how large-scale transitions generally happen, which can be used as a tool to help guide policies and strategies that promote sustainable transitions – including those in food systems.

This framework – known as the *multilevel perspective* – looks systemically at society, technologies and economies, and what developments (or changes) are taking place at three different levels (or scales) of analysis, focusing in particular on how the interactions between these different levels promote or resist changes in the overall system. The three levels of analysis are: *niche innovations* (new technologies and business models); *sociotechnical regimes* (established practices, technologies, institutions, organisations and rules specific to the dominant ways of doing things today); and the *sociotechnical landscape* (the external context of large-scale and longer-term political, socioeconomic and environmental trends).<sup>367</sup>

Broadly speaking, the framework suggests that large-scale transitions (e.g. the motorisation of transportation) can happen at a specific time and place (and not in others) because of the specific types of interaction between processes occurring at each level of analysis. These can sometimes influence each other in such a way that the established structures and ways of doing things start to fail, and so become destabilised; while at the same time innovations appearing at the niche level can first gain a foothold and later momentum (e.g. through learning processes, combination with other innovations, price/performance improvements and support from powerful players). In doing so, ways to overcome factors (e.g. economic, technical, political, cultural, infrastructural) that lock in the dominance of the existing sociotechnical regime can be found. Ultimately, this can result in a breakthrough of new innovations into the mainstream, some of which may even grow to become the new normal<sup>368</sup>.

When it comes to applying this framework to transitioning to a low-emissions food system, the available evidence set out in this report suggests that the world now finds itself at the cusp of a unique 'window of opportunity' for systemic change. Rapid technology-enabled improvements in the quality, production volume and cost-competitiveness of meat alternatives (i.e. *niche innovations*), and the business models for their marketing and provision to consumers, are taking place at the same moment that established ways of consuming are being disrupted by demographic and culturally driven shifts in eating preferences, in part linked to the growing availability of information about foods' impacts on health and the natural world (i.e. *landscape-level changes*).

As has been the case with renewable energy, whether this window of opportunity will lead to a large-scale transformation of the food system, and with it a transformation of diets, will depend on whether a robust policy framework is put in place to set science-based targets and coordinate and incentivise change towards achieving them. Yet, if policymakers worldwide are truly committed to taking the necessary action to meet agreed global goals for climate, sustainable development, biodiversity and food security, the eventual establishment of policies aiming to shift diets would seem inevitable. The remainder of this chapter further explores the actions different players can take to accelerate or hamper this transition.

## 7.2. Lack of policies supporting low-carbon transition in the food sector

While the market for plant-based food products has been growing, public policy and public sector bodies have yet to make any significant contribution to this trend by encouraging a shift in food consumption towards diets that are both healthy and sustainable – and so generally higher in plant-based foods – than a typical Western diet. Despite the mounting evidence that excessive consumption of meat is bad for both the climate and public health, governments have not made much effort to promote more plant-based diets or sustainable methods of food production.

Contrasting with the agri-food sector is the energy sector, where governments have put in place a range of interwoven public policies that support its overall decarbonisation. These include targets and subsidies for renewable energy sources, targets and public procurement policies driving more energy efficient products, and pricing carbon to drive investments towards cleaner production processes. In the transport sector, governments have put in place road charges; fuel taxes; policies to increase fuel efficiency in cars, vans and trucks; policies and funding new charging infrastructure for electric cars, etc. In both sectors, policies are complemented with research funds dedicated to innovation for new energy sources; for example, through the multibillion-euro NER300 programme.<sup>369</sup> These policies exist on many levels, ranging from international commitments (the Paris Agreement) to EU policies, and to national and even local policies – recently, many cities have committed to green energy and energy efficiency, put in place congestion charges that promote more efficient cars, built electric charging infrastructure, etc.<sup>370</sup> These policies create investment certainty for business and drive private investments towards low-carbon technologies.

In contrast, we found very few similar policies that are designed to drive a low-emissions transition in food. Despite parliamentary debates on taxing meat taking place in Germany, Sweden and Denmark, and a range of policies having been proposed by respected think tanks such as Chatham House, this debate hasn't moved towards comprehensive policy action in a single country.<sup>371</sup> We only see slow and somewhat patchy initiatives at the local level. In the UK, 14 cities and local areas recently received funding from Sustainable Food Cities to run Veg Cities campaigns, which aims to promote vegetable consumption

through schools, events and festivals.<sup>372</sup> Similarly, some cities, like Ghent, have been supporting meat-free days since 2009; while others, like Barcelona, have developed a vegetarian guide of the city, joined the Meat Free Mondays campaign and created a space to promote the sector, after declaring itself a veggie-friendly city in 2016.<sup>373,374</sup>

While commendable, it is obvious that these attempts are nowhere near the robust, population-influencing governmental policies required. No country has policies encouraging meat-free days or places, or even measures to ensure a consistent range of non-meat dietary options for consumers, which could be seen as providing social occasions and spaces for people to acquaint themselves with more sustainable and healthy ways of eating. Reducing meat consumption could also be a good opportunity to provide healthier and more locally sourced food, especially to populations such as schoolchildren and hospitals. These could be combined with promoting better farming methods and encouraging companies, such as restaurants and food retailers, to increase the share of healthy meat-free meals in their product ranges.

Food and agriculture policies still mostly ignore the full scale of environmental and social impacts that result from food production and consumption. In fact, subsidies are currently driving the expansion of intensive farming methods, including vast animal-feed imports, and passing costs of cleaning up agricultural pollution and dealing with public health issues derived from excessive consumption of animal products to the public purse. In the EU, for example, almost 60 billion EUR per year is mostly going to intensive farming, marginalising sustainable farmers. Through such harmful subsidies, the positive externalities of more sustainable agricultural methods, such as organic, high nature value or agro-ecologically managed agricultural systems, are not properly realised or rewarded.<sup>375</sup>

Finally, emissions from animal agriculture continue to be a major gap in global climate policy – or when they are included in a legal framework for reducing CO<sub>2</sub> emissions (such as in the EU<sup>376</sup>), measures are so weak that they are unlikely to lead to any significant emissions reductions (see Chapter 2). All in all, this lack of regulatory action amounts to overpricing consumers, who must pay for food three times over: at the shop; through their taxes that are spent on farming subsidies; and through the negative externalities forced upon society at large, such as environmental degradation of soil, water and air; biodiversity loss; non-renewable resource use; public health impacts, and social development issues related to food access and consumption.

### Upside-down European policy: polluter gets paid

One of the key objectives of the European Common Agricultural Policy (CAP), which distributes around 60 billion EUR per year (40% of the EU budget) to farmers, is improving the environment. However, a 2018 report from Greenpeace suggests that CAP actually achieves the opposite.<sup>377</sup>

The Greenpeace-led investigation conducted in eight countries – Austria, Belgium, Denmark, France, Germany, Italy, Poland and the Netherlands – concluded that there was a clear pattern between CAP subsidies and the most polluting European livestock farms. The underpinning reason, according to Greenpeace, is that *'the negative health and environmental impacts of the livestock sector are not properly monitored nor assessed, neither at national nor at European level'*.

In particular, the research highlighted that the design of existing environmental regulations on farm pollution is encouraging investment away from smaller farm sizes and more sustainable production

methods and towards larger-scale intensive farms. One of the reasons for this is that the threshold for reporting on ammonia pollution is set very high: farms releasing less than 10,000kg of ammonia per year – the amount that would be generated by 40,000 chickens, 2,000 pigs or 750 piglet-bearing sows. This high limit has allowed large parent firms collecting CAP subsidies to simply game the system by legally dividing their operations on paper, with each polluting up to the maximum allowed by the regulations before authorisation from environmental authorities is required.

This lack of regulatory oversight has led to a paradoxical situation where on the one hand, taxpayers contribute to CAP subsidies that further develop industrial livestock installations; and on the other, taxpayers pay to clean up the pollution that these farms then create.<sup>378</sup> In Greenpeace's words: *'the "polluter pays" principle enshrined in the EU Treaty, which should underpin all EU legislation, has transformed into the "polluter gets paid" principle'*.

Ongoing work from the International Panel of Experts on Sustainable Food Systems (IPES-Food)<sup>379</sup> is looking at how policies can be reformed to integrate all aspects of food policy (health, environment, food, development, etc.) into their design. Proper integration of these issues will ensure price signals are set correctly, reflecting the true costs of producing food to society – and hence encouraging the consumption of the most sustainable food products while discouraging the least sustainable ones.

### Mixed messages on dietary advice funded by the public purse

Consumption of meat and dairy products in the EU and US has reached excessive levels and is now a major burden on public health through increased incidence of cancer, diabetes and other diseases. The health impacts of eating too much meat – especially processed meat – are driving some governments<sup>380</sup> (including China<sup>381</sup>) and European countries (e.g. the UK, France, the Netherlands and Sweden) to set recommended levels of meat consumption in their dietary guidelines. The Swedish Food Agency (SFA) was the first governmental body to also include the environmental impacts of food production in its 2014 dietary guidelines, which recommended eating less red and processed meat (a maximum of 500g per week), as meat is the food product that affects the climate and the environment the most.<sup>382</sup>

Yet at the same time, public policies often push in the opposite direction, heavily subsidising and promoting meat consumption. Despite excessive consumption levels and large environmental impacts associated with current EU diets, the European Commissioner for Agriculture pledged 15 million EUR in 2016 to promote beef consumption *'to counter negative publicity about eating animal proteins'*,<sup>383</sup> ignoring complaints from NGOs.<sup>384</sup>

Similarly, in the US, The Beef Checkoff Program was established as part of the 1985 Farm Bill. It allows producers to charge 1 USD per head on the sale of live domestic and imported cattle to fund marketing and research designed to increase domestic and/or international demand for beef, through promotion, research, new product development and a variety of other marketing tools. The Cattlemen's Beef Board and United States Department of Agriculture oversee the collection and spending of checkoff funds, which in 2017 amounted to 41 million USD.<sup>385</sup> Similar controversial systems provide multimillion-dollar funds for the promotion of other agricultural commodities (including pork,<sup>386</sup> dairy and eggs<sup>387</sup>) and have actively been using this money for lobbying activities – including against the promotion of plant-based alternatives.<sup>388</sup> Unsurprisingly, the US has one of the highest meat and dairy consumption rates in the world.<sup>389</sup>

Public funds directed to research and development projects in the area of agriculture have also largely avoided supporting alternative meat and dairy production technologies, even in countries with large research budgets such as the US (3bn USD annually).<sup>390</sup> The bulk of early-stage support and financing for animal-product alternatives continues to come from private, not public, sources. Indeed, in many ways public funding flows predominantly support the status quo; in many regions, large amounts of funding are still being used to subsidise production, promote demand for animal products, and support R&D work focused specifically on animal agriculture protection (improved disease detection, prevention, control and treatment, etc.) and production (technologies to increase efficiency and product quality, etc.).<sup>391,392</sup>

Nevertheless, some governments are waking up to the potential opportunities that investment in clean meat may bring. For example, the Japanese government has just invested 300 million USD in supporting the construction of a pilot and first commercial production plants for **Intergiculture**, a company specialising in cellular agriculture products.<sup>393</sup> The US's pro-plant-based organisation, GFI, suggests that Israeli and Indian governments may follow soon.<sup>394</sup> Israel is leading the race (behind California) to be a world hub for cultured meat technologies. Recently, three Israeli companies – **SuperMeat**, **Future Meat Technologies** and **Meat the Future** – signed a deal to supply cultured meat to China worth 300 million USD.<sup>395</sup> However, these funds are still scarce and small in scale when compared to the urgency of the problems the world faces, and nowhere are they accompanied by strong public policies targeted to shift demand away from climate-damaging foods.

### 7.3. Can the business sector solve this problem alone?

The previous chapter illustrated how profitable many plant-based food brands, such as Quorn or Alpro, have become. Plant-based dairy products are taking away a significant part of the traditional dairy market, and meat replacement products' market share is also growing fast. Through documentaries, celebrity influencers, increasing traditional media coverage and social media, the message in favour of shifting diets towards plant-based foods is reaching more and more citizens.

In turn, these trends in public attitudes are driving change within the strategies of some far-sighted businesses that are responsive to the shifting demands of their current and future customer base; many are trying to adjust their public messaging, and starting to make commitments to increase their offering of plant-based foods and to address the sustainability of their operations and those of their suppliers. This is encouraging, as many studies highlight the benefits of building acceptance for the proposed changes (within society and the business community) as a way of supporting the introduction of new policies and legislation designed to promote a dietary shift.<sup>396</sup>

Business support can accelerate the development of new and better products, their deployment through established distribution channels and, more generally, the provision of financial resources and capabilities needed to accelerate the transition towards plant-based foods.<sup>397</sup> However, as highlighted in the box below, just relying on business to do the right thing – especially when it comes to incumbents (companies that have large sunk investments into existing business models) – can be a risky strategy. The main problem is that companies can quickly change priorities, following a change in leadership, a (perceived) change in consumer preferences or a realisation that a company's bottom line crucially depends on guarding the hegemony of existing technologies. In addition, while companies sometimes try to respond to public concerns by presenting a green image, their investments and lobbying often take the opposite stance, and are deployed to block or delay policies that would force change in their practices towards more sustainable economy.<sup>398</sup>

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### BP's round trip to petroleum

The history of the oil industry's investment in renewables is a cautionary tale, illustrating how volatile corporate commitments can be. In 1997, BP's CEO, John Brown, became the first big oil chief to acknowledge the link between man-made carbon emissions and global warming. This was followed by BP rebranding itself as an environmentally aware company, supporting an increase in renewable energy supply and a reduction of the GHG emissions associated with its fossil fuel business. It culminated with the company ditching its shield-like logo in exchange of one in the shape of the sun, '*signifying dynamic energy in all its forms from oil to gas and solar*'.<sup>399</sup>

In an opinion piece,<sup>400</sup> John Brown talks about the challenges associated with persuading BP's board, executive and employees that his vision for BP '*was not about to commit commercial suicide*'. Initially, BP achieved its own voluntary target of a 10% CO<sub>2</sub> reduction for 2010 nine years earlier (in 2001). These reductions were largely made at the margins by '*tightening up valves, halting the venting of gas and improving energy efficiency*'. BP's investment in renewables could have been transformational. At one point, BP was the leading US solar panel manufacturer; but within a couple of years, it abandoned the business.<sup>401</sup>

This move, which involved dropping businesses worth billions, included BP shutting down its alternative energy headquarters in London and cutting drastically its alternative energy budget in 2009,<sup>402</sup> retreating from solar in 2011 and from wind and other areas (such as carbon capture and storage) in 2013.<sup>403</sup> In the solar sector alone, an article in *The Guardian* reports the complete closure of all BP's solar panel factories in 2011, making 1,750 workers redundant.<sup>404</sup>

Current CEO, Bob Dudley, maintains a similar position; he claimed in a recent *Washington Post* interview that '*if someone said, "Here's \$10 billion to invest in renewables," we wouldn't know how to do it*'.<sup>405</sup> Nevertheless, in June 2018, BP bought UK's biggest electric car charging network, **Chargemaster**,<sup>406,407</sup> and purchased a 43% interest in solar-development firm **Lightsource**. Renewable investment may reach 500 million USD a year, a tiny traction of the more than 15 billion USD capital spending. Mr Dudley believes that '*the evolution of the energy markets is going to take decades and decades and decades*',<sup>408</sup> and that the future is in gas (which is not in line with what most climate scientists think is necessary).

Evidence also points to the fact that BP actively lobbied European institutions to weaken environmental and clean energy policies. *The Guardian's* investigation showed how BP strongly opposed renewable energy subsidies; restrictions on the most polluting biofuels; laws to regulate tar sands; cuts to power-plant pollution; and policies to promote clean technologies. BP warned that such measures '*threaten to drive energy-intensive industries, such as refining and petrochemicals, to relocate outside the EU with a correspondingly detrimental impact on security of supply, jobs [and] growth*'.<sup>409</sup> Such lobbying by BP and other companies resulted in the weakening of some key regulations, and has also led to the removal of figures that revealed EU states spent 40 billion EUR a year on subsidies for fossil fuels, compared to 35 billion EUR for nuclear energy and just 30 billion EUR for renewables.

The BP example shows how dangerous it is to leave the urgent transition towards climate-friendly technologies in the hands of corporations that benefit significantly from status quo. In this regard, the parallel between the meat industry (which benefits from growing global meat consumption) and energy companies such as BP (which benefit from maintaining and growing global demand for fossil fuels) is clear to see, and sounds a note of caution when looking at the meat industry to solve the problems it creates. While the private sector can and must play a role, the transition must be underpinned by strong policies and independent monitoring, with high levels of transparency about companies' performances and impacts.

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## 7.4. Strong policies critical for low-emissions transition

Truly transformational changes in societies are normally processes that unfold over decades (e.g. the telephony and personal computing revolutions) because changing global systems, even at a rapid pace, takes time to scale up. However, slowly at first and later more quickly, what was niche or novel grows from a tiny percentage of the market or society to become dominant and fully integrated, as all the institutions, organisations, regulation, infrastructure, social norms and more are eventually reconfigured around the change to form a new system and establish a new 'normal' way of doing things.

Such large-scale changes are inevitably politically contested, because with sweeping change come winners and losers. While a change may benefit humanity overall, for established players that stand to lose out from a change, investment in lobbying and other means to stop or delay 'harmful' legislation or hold back potential competitors pays for itself many times over. Unfortunately, with a few notable exceptions, incumbent businesses consistently fail to respond to system threats to their companies and business models. They can see the threats, analyse them and develop strategies to respond, but they generally fail to deliver these strategies – and so they often end up among the losers of transitions.<sup>410</sup>

Yet despite this resistance to change, large-scale transformations have happened constantly *throughout* history, and are certainly underway today. And what was politically acceptable once (e.g. limiting the vote only to men) can be overturned in less than a generation. A striking example is Fortune 500 firms – of those in existence in 1995, only 60 remain today.<sup>411</sup>

Sustainable transitions, such as a low-emissions transition in food, are qualitatively different; rather than leaving the future (and humanity's wellbeing) to chance, there is a strong argument for trying to agree exactly where we, collectively, would want to end up. To put it another way, sustainable transitions are those where the course of history is *intentionally* being bent towards a more sustainable direction, and where the pace of change is dictated by a specific goal – in the case of climate change, a goal forced on us by the physics and chemistry of our universe. To achieve such truly transformational changes, independent and local-level actions are simply not enough.<sup>412</sup> Driving change at scale requires coordinated action across economies and societies, driven by a range of mutually reinforcing policies that set incentives for businesses, regulators, the public, etc., and that enact changes to infrastructure, regulation and more that hold back or slow down change.

For areas of policy such as energy, legislation aiming to drive sustainable transitions towards renewable sources of power has been on the books for decades, and is now leading to a widespread revolution in electricity production globally. The need for such policies is perhaps even greater when it comes to food production and consumption, and, in particular, policies targeted at enabling and driving a dietary shift towards sustainable and healthy diets that eliminate excessive levels of meat and dairy consumption. Yet, to date, no government has taken up this issue in line with the scale and urgency necessary.

However, as has been detailed in this report. A window of opportunity for change has now emerged, driven by a constellation of new technologies, companies, investors and social trends and linked, in turn, to increasingly clear science and public knowledge about food's environmental impact.

Driving change also means favouring winners over losers and encouraging disruptors inside the corporate world to support and accelerate the transition to a low-emissions food system. There are clearly companies that will benefit from the scale-up of plant-based and clean-meat technologies. Clear winners will also be

the farmers who produce vegetables, pulses and other foods that could be encouraged by governmental policies designed to promote more sustainable and healthy diets. Freeing up large amounts of land that is now occupied to support intensive animal farming systems could also enable more sustainable – although more land-intensive – production of meat and dairy products. Big winners of such a shift would also include the public health purse, as less money would have to be spent on diet-related diseases.

## 7.5. Will people embrace low-carbon transition?

The fear of public backlash for telling people what to eat has often been cited as one of the main reasons for governmental inaction in this field.<sup>413</sup> However, Chatham House's multicountry opinion survey has found a general belief across cultures and continents that it is the role of government to spearhead efforts to address unsustainable meat consumption. Governments overestimate the risk of public backlash, and the Chatham House report concluded that *'increasing public awareness about the problems of overconsumption of animal products can help disrupt the cycle of inertia, thereby creating more enabling domestic circumstances and the political space for policy intervention'*.<sup>414</sup> The researchers recommended focusing on the benefits to public health systems and subsequent cost savings in national health budgets, and framing proposed policies to promote sustainable resource use and contribute substantively to the decarbonisation of economies.<sup>415</sup> This research is also underpinned by consistent findings about public concern over climate change. A recent study shows that over 70% of British public are now concerned about climate change, and that young people in particular want more political attention afforded to this issue.<sup>416</sup>

*Concerted efforts should be made at international level to assess the relative resource intensity of different diets and food groups, and to arrive at a common definition of what a 'sustainable diet' looks like – both across different cultures and in view of future resource constraints and growing global demand for calorie- and protein-rich foods.*

**Chatham House, Changing Climate, Changing Diets report**

The primary drivers of consumer food choice are price, taste and convenience.<sup>417</sup> The Chatham House report points out that greater availability of vegetarian and vegan alternatives and lower-meat options among pre-prepared meals, as well as preferential positioning of alternatives in shops and schools, could go a long way towards altering consumer choices. Local governments and public procurement policies can play an important role here. Price is also a very important driver in food choices, and governments can play a role through rebalancing the relative costs of meat and dairy products, thereby improving access to diverse and healthier diets. As most policies currently go in the opposite direction, driving higher consumption of meat and dairy products through both subsidies and promotion campaigns, readjusting these to better fit climate objectives would be a good first step.

Taxing products with high-GHG emission profiles could also be a good option and, as the example of the 'sugar tax' shows, small taxes can already influence purchasing decisions (another example is the 5p plastic bag charge, which led to an 80% reduction in plastic bag use, accompanied with a campaign on ocean pollution).<sup>418</sup>



Growing market demand for meat alternatives, which are tasty, healthy and convenient, provides a great opportunity for policymakers to start putting in place policies that drive the low-emissions transition in food. The investment history of the oil industry has shown that the investment in alternatives cannot be left solely to incumbent business players. In the energy and transport sector, we also had significant independent voices, such as numerous solar and wind energy firms and innovative companies like Tesla. The success of these companies depended solely on the success of the low-carbon alternative technologies they were selling, which made them truly disruptive for incumbents. While we acknowledge that food sector is different, it must follow similar principles as the energy and transport sector: phasing out the worst sources, while at the same time investing and promoting the market for the alternatives.

Independent disruptive companies are also critical in ensuring political support for such policies. After all, is it realistic to expect dairy and meat giants, such as Danone, Nestlé, Tyson or Maple Leaf, to support the introduction of taxes on animal products, or pricing of emissions associated with livestock, just because of their recent and relatively small investments in the plant-based food market? This is definitely a diversification strategy, but the history of fossil fuel and energy utility companies' investment in renewables also shows a different story. A 2015 article in *The Guardian* revealed how fossil energy companies bought a significant market share in the renewable industry and then used their influence to steer the position of key renewables trade groups towards a pro-gas stance, which weakened Europe's 2030 clean energy targets. This, according to the article, was part of a deliberate strategic move that started in 2009, when big companies started to realise renewables were suddenly becoming system-dominant and decided: *'If you can't beat them, join them. And if you join them, slow them down so that you can survive in the market'*.<sup>419</sup>



## Sticks in the wheels: conventional vehicle manufacturers fight transition towards low-carbon cars

The ongoing battle to move the automotive sector towards low-carbon technologies provides an interesting case study on how powerful incumbent companies have undermined or delayed progressive policies, and how this has backfired in the latest emissions-cheating scandal. This case study is focused on the EU and policies that set out CO<sub>2</sub> emissions standards for cars in the EU market.

The first political discussions at European level on how to address carbon emissions from vehicles date back to 1995.<sup>420</sup> Under growing pressure from the regulatory bodies, in 1998 European car manufacturers and their Korean and Japanese counterparts agreed to a voluntarily 25% CO<sub>2</sub> emissions reduction target (from 186 to 140g/km) for cars sold in Europe by 2008/9.<sup>421</sup>

In the mid-2000s, the apparent failure of the voluntary measures alone to deliver the agreed targets drove the European Environment Commissioner, Stavros Dimas, to start considering legal obligations in what was to become one of the biggest political fights during his term. Despite the opposition of the European car manufacturers' association (ACEA), the Commission managed to set mandatory targets of 130g/km to be reached by 2012, and a long-term target for 2020 that had to be confirmed through another political process.<sup>422</sup> Very high-level political infighting continued for five years; in 2013 the German Chancellor, Angela Merkel, even moved to water down the agreed goal of 95g/km of CO<sub>2</sub> by 2020. While these targets focused engineers' minds and capacity to work on emission-reduction technologies, the fight was not over yet. All the major carmakers have been increasingly exploiting flexibilities in the official emission tests, to the extent that the real emissions are estimated to be between one-quarter (Mazda) and double (Mercedes) those reported.<sup>423</sup> The most infamous scandal broke out when Volkswagen (VW) was found to have installed defeat devices on its car fleet worldwide to dodge official controls on car emissions legislation.<sup>424</sup> 'Dieselgate' increasingly undermined public and political confidence that diesel technologies can deliver the necessary reductions, and attention has since shifted towards electric cars.

But the transition to electric vehicles (EVs) is not easy, and major car manufacturers are delaying this shift due to sunk investments in current proprietary technologies, which could become a form of stranded asset if the electric revolution happens too fast.<sup>425</sup> A recent Bloomberg article on VW shows that, although in the wake of the cheating scandal VW has one of the highest EV targets of all car companies, it must still persuade its customers to start buying diesel cars again. With billions in capital investments sunk into diesel technologies over many decades, VW does not want the transition to EVs to happen too quickly or disruptively – which is exactly the opposite of what is needed to meet our climate targets.<sup>426</sup>

A recent report from NGO Transport & Environment shows that manufacturers are doing very little to market electric cars. While 30% of German, French and British consumers say they would consider buying an EV, just 2.1% of car marketing spend was on zero-emission vehicles and 1.6% on plug-in hybrid models. The report found that manufacturers had only 20 battery EVs on sale compared to over 400 conventionally fuelled models, with many models not available for sale in showrooms and others having long waiting times.<sup>427</sup> In 2017, fewer than 2 out of each 10 electric cars sold worldwide were in Europe (mostly in France, Norway, Germany and the UK), compared to 6 out of 10 in China.<sup>428</sup>

The shift towards EVs places the incumbent internal combustion engine (ICE) manufacturing industry at a competitive disadvantage against EV-focused disruptors such as Tesla, Google and Apple. This is because electric motors are essentially a different product to build (easier to build than ICEs, with different technologies, etc.), requiring a resetting of the core expertise needed to produce a great automotive product. This may give a competitive advantage to companies in other sectors (e.g. consumer electronics or software developers) over traditional car manufacturers, as the former have greater experience in key EV technological issues such as battery life, power optimisation or software development.<sup>429</sup>

## 8. Conclusions and recommendations

This chapter has shown that strong policies (targets, carbon taxes, etc.) and disruptive industry players that supply new technologies (i.e. independent renewable energy providers and electric car companies) are key elements that can accelerate and support low-carbon transitions in different sectors. It has also highlighted the lack of ambitious policies in the food sector, where public subsidies are still largely driving unsustainable animal agriculture, which is at odds with the 1.5°C climate pathway that governments have committed to. And it has shown that, even with policies, policymakers can expect resistance from incumbents, which often slows down the market expansion of new technologies, such as electric cars. While each sector is different, low-carbon transitions in the energy and transport sectors can provide some valuable lessons for managing the transition in the food industry. Governments can manage through effective incentives and adaptations, especially for livestock and feed farmers. Since these farmers have already started feeling the effects of climate change, through recurring draughts and similar extreme weather events, the reform of the sector should not be further delayed.

This report has summarised the growing amount of evidence of the negative environmental, health and taxpayer impacts associated with overconsumption of meat and dairy products. Feeding a growing population on a planet of finite resources will require shifting to more efficient, low-resource diets. The case for change is now so compelling on environmental, climate and health grounds that the question is not *whether* change needs to happen but *when* and *how* it will happen. It can either happen soon and in a managed way, with governments, companies and consumers shifting to diets that are lower in meat and dairy and healthier for people and planet, or it will eventually happen through chaotic adaptation to collapsing agricultural systems, as climate change is already starting to impact on food production everywhere.<sup>430</sup>

Concerns over the devastating impacts of livestock production on the environment and on animals themselves have been known for years, but few advocacy organisations or governments have ventured into this field and taken action, fearing a public backlash against what is largely considered a personal choice. Farming lobbies have also been successful in stopping even small changes in public policies or redirection of subsidies towards more climate-friendly and healthier diets and agricultural production systems. Despite the numerous reports and scientific studies highlighting that sustainable levels of meat and dairy consumption, for both personal health and the health of our planet, are far below levels of current consumption in high-income countries, not much has happened in this field beyond shifting market preferences.

This is problematic, because the low-emissions transition in the food sector will not just happen automatically. Indeed, current government policies are actively promoting and incentivising animal agriculture products through various subsidies and support measures. The food industry is a highly concentrated sector, which has proven very resilient to change and to policy reform. This report highlights some examples of the meat industry's reactions to even small signs of public and political support of reducing meat consumption. The executives of big corporations see their duty to shareholders or private owners as, above all else, maximising short-term profits, and they largely believe this should be done without any interference from politicians – even though the fight against climate change can only be won if governments show leadership, both individually and collectively.<sup>431</sup> While some of the big companies have slowly started to invest in meat alternatives, most do not have robust strategies to align themselves with science-based climate targets. In addition, lessons from other sectors (transport and energy) show that incumbents mostly do not support disruptive alternatives when these could affect their bottom lines

or sunk investments. Even if a small share of their investment is in the solution to climate change, the example of vehicle manufacturers shows they are still trying to slow down the penetrating of electric cars due to their sunk investments in the internal combustion engine.

This brings us to a significant gap highlighted by this report: the absence of policies to drive reduction in meat and dairy consumption, and to promote more sustainable diets and food-production systems. Even worse, most policies are designed to cater to the incumbent, very intensive and polluting livestock farms and big meat conglomerates. These policies range from direct and indirect farming subsidies to public money being used for the promotion of meat and dairy consumption (as the meat industry is very afraid of the trend of millennials eating less meat). Instead of promoting more sustainable and climate-friendly farming systems, governments continue to subsidise conventional animal agriculture methods, allowing the *'polluter to get paid'*. The message for policymakers and industry is simple – climate action in this sector cannot wait any longer, and the window of opportunity to meet internationally agreed climate targets is closing.

On the positive side, the transition towards a low-emissions food system is in many ways easier to realise than in other sectors, such as energy and transport. This is because there are no big infrastructure investments, such as building new electricity infrastructure or EV charging systems, while production cycles are shorter because farmers can, to some extent, switch crops and the way they manage their land – when given the right incentives to do so. In addition, tackling emissions from the livestock sector can be a significant opportunity, as this sector roughly contributes to one-third and two-thirds of all man-made methane and nitrous oxide emissions respectively. Studies have shown that steeper reduction trajectories for high-warming gases would facilitate adaptation to evolving climate change and help achieve a lower temperature-increase goal (1.5°C).

The transition towards a low-emissions food system needs to be nurtured and accelerated as a strategic multinational priority. Momentum is building as more and more people turn to flexitarian, vegetarian and vegan diets, and plant-based foods are one of the fastest-growing food categories. However, the complete absence of public messaging and policies to promote a shift towards plant-based diets means this critical dietary shift is left to the whims of the market and personal choice. Aligning subsidies and taxation with the most sustainable food-production methods and products – which are better for the climate, biodiversity, the wider environment and animal welfare – would undoubtedly accelerate the pace of current consumption trends.

Moreover, public R&D investments are still focused on traditional agriculture methods, while the food industry's spending on R&D is tiny (less than 1%). Although a low-emissions transition does not require a huge technological shift (as in the energy and transport sectors), there is a case for more investment in clean meat and animal products, as these may prove to be a suitable lower-impact substitute for committed carnivores – replacing, in particular, low-quality and low-animal-welfare processed meats, which make up a large part of current demand for meat. For many others who are more flexible in their protein consumption, plant-based meat replacements already exist and are improving rapidly. And, of course, if it were simply a matter of nutrition, vegetables, legumes, nuts and fortified foods can provide all the nutrients necessary for a person to switch consumption and remain healthy. The creation of a favourable policy and regulatory environment is likely to accelerate the transition through increased investments into faster product-improvement cycles and lower production costs, enabling faster commercialisation and scaling-up of clean-meat and plant-based products.

The industry is truly at a crossroads, with this year's draughts affecting the livestock sector very badly. Paradoxically, European farmers have used the situation to ask for (and achieve) the suspension of some of the few environmental measures related to the farms and for additional financial support. This means further exacerbation of environmental problems, without any medium- to long-term measures to tackle vulnerabilities in the system or transition to more climate-resilient agriculture (and, correspondingly, more plant-based diets). It is clear that pouring more taxpayers' money into this sector is not going to solve the problems it is starting to face.

Governments must set a clear trajectory for the transition to give certainty to companies and investors, help farmers to adjust to these changes, and create an engaging and desirable vision for citizens of how one of the most important problems of our era can be addressed. The arguments in favour of health, animal welfare and the environment are overwhelming. Given the inevitability of change in the sector, the opposite will only lead to chaos.

## Policy recommendations

These policy recommendations are a non-exhaustive list of measures that can be implemented at several levels: national, regional or global. The Global North and high-GHG emitters should take the lead in the low-carbon transition of their food sectors. As they are the biggest producers of meat and some of the largest importers of feed, their actions will spill beyond national borders. To realise the highest possible benefits of low-carbon transition, it is important to complement demand-side measures (aiming to reducing demand for the unhealthiest and environmentally problematic animal products) with supply-side measures (to shift agricultural production towards more climate- and biodiversity-friendly methods). The right incentives for farmers can be set through restructuring existing subsidies and establishing new climate funds, especially aimed at the Global South, with a view to improve local nutrition.

***'Several studies conclude a 50% reduction in current consumption of [livestock] products in the EU would make a significant contribution to climate change mitigation and align current intake of animal protein and fats with WHO recommended dietary guidelines.' This could lead to 40% less reactive nitrogen emissions from agriculture and 23% reduction in cropland area. The Rise Foundation<sup>432</sup>***

**Update climate targets to include the mitigation potential of animal agriculture.** Governments should determine what role the reductions in animal products and the shift towards more sustainable agriculture can play in their nationally determined contributions. They should analyse the hotspots in their emissions sources and address ways to reduce the impacts. Preferred options for biodiversity, such as permanent pasture utilisation, should be given priority. A recent Rise report highlighted that, in most EU member states, the proportion of current animals justified to maintain pastures is small: less than 30%, or between 30% and 60%. The report also highlighted that most EU countries do not include agriculture in their targets, which means its emissions share will grow while other sectors decarbonise.

**Update fiscal policies to reduce meat demand and consumption, especially where consumption exceeds health recommendations.** In many EU countries, and in the US, meat consumption is double the recommended levels. So-called 'meat taxes' have been recommended by several reputable institutions – a tax on goods deemed unhealthy and/or damaging to the environment. According to FAIRR, over 180 countries now impose a tax on tobacco, 60 jurisdictions tax carbon, at least 25 tax sugar and some countries are considering taxing meat.<sup>433</sup> International organisations such as WHO are well suited to support such measures and analyse different trade-offs, as they did with tobacco.

**Establish implementation strategies for dietary guidelines for the shift to healthier diets, including the reduction of animal products.** The dietary guidelines should include recommendations to reduce the consumption of meat and other animal products and include environmental criteria for food production and consumption, as is the case in Sweden. To maximise their impacts, they should be followed by key public institutions (such as schools) and integrated in public procurement policies and at several other levels. Meat-free initiatives and areas at national and local levels should also be encouraged. Dietary guidelines should be followed by public awareness-raising and health-education campaigns.

**Shift subsidies away from polluting intensive animal farms and address the negative externalities of animal agriculture.** Governments should aim to reduce the size and number of factory farms, starting with restructuring existing overcapacities. International institutions (WHO, EU, FAO, etc.) should discourage their member states from subsidising factory farming and its inputs, as these cause significant harm to the public.<sup>434</sup> Important measures in this context are bans that should be considered for the use of antibiotics for growth promotion and 'disease prevention' in animal farms. The meat industry should be obliged to dispose of antibiotics, manure and other wastes and emissions from its processes in ways that prevent environmental contamination and reduce GHG emissions. This would align money transfers from subsidising polluting activities towards the 'polluter pays' principle. In this context, governments should consider time-bound transition measures for farmers in order to manage transition towards more sustainable practices.

**Incentivise the production of diverse and underused protein crops, such as pulses, for human consumption.** Producing more leguminous crops, especially when part of a solid crop rotation, can help contribute to climate mitigation and adaptation by reducing amounts of water and fertiliser used, cutting pesticide dependency and increasing soil fertility and yield.

**Fund the research and development of plant-based and other meat alternatives, such as clean meat,** which have the potential to eliminate or reduce the harms of factory farming.

## The list of references

- 1 Food and Agriculture Organisation of the United Nations (2018) Food outlook: Biannual report on global food markets. [ONLINE] Available at: <http://www.fao.org/3/ca0239en/CA0239EN.pdf>
- 2 Food and Agriculture Organisation of the United Nations (2018) Sources of meat. [ONLINE] Available at [http://www.fao.org/ag/againfo/themes/en/meat/backgr\\_sources.html](http://www.fao.org/ag/againfo/themes/en/meat/backgr_sources.html)
- 3 Food and Agriculture Organisation of the United Nations (2018) GLEAM 2.0: Assessment of greenhouse gas emissions and mitigation potential. [ONLINE] Available at: <http://www.fao.org/gleam/results/en/>
- 4 Bailey, R., Froggatt, A. & Wellesley, L. (2014) Livestock: Climate change's forgotten sector: Global public opinion on meat and dairy consumption. Chatham House.
- 5 Bajželj, B. et al. (2014) Importance of food-demand management for climate mitigation. *Nature Climate Change*, 4(10): 924–929.
- 6 Foley, J. A. et al. (2011) Solutions for a cultivated planet. *Nature*, 478, 337–342.
- 7 'Biodiversity' refers to the variety of ecosystems, species and their genetics that exist from global to local scales.
- 8 Walsh, B. (2013) The triple whopper environmental impact of global meat production. *Time*, 16 December 2013. [ONLINE] Available at: <http://science.time.com/2013/12/16/the-triple-whopper-environmental-impact-of-global-meat-production/>
- 9 Smithers, R. (2017) Vast animal-feed crops to satisfy our meat needs are destroying planet. *The Guardian*, 5 October 2017. [ONLINE] Available at: <https://www.theguardian.com/environment/2017/oct/05/vast-animal-feed-crops-meat-needs-destroying-planet>
- 10 Hance, J. (2015) How humans are driving the sixth mass extinction. *The Guardian*, 20 October 2015. [ONLINE] Available at: <https://www.theguardian.com/environment/radical-conservation/2015/oct/20/the-four-horsemen-of-the-sixth-mass-extinction>
- 11 Smithers, R. (2017) Vast animal-feed crops to satisfy our meat needs are destroying planet. *The Guardian*, 5 October 2017. [ONLINE] Available at: <https://www.theguardian.com/environment/2017/oct/05/vast-animal-feed-crops-meat-needs-destroying-planet>
- 12 World Health Organization (2018) Antibiotic resistance. [ONLINE] Available at: <http://www.who.int/news-room/fact-sheets/detail/antibiotic-resistance>.
- 13 The Guardian (2018) French MPs force vegetarian food producers to mince their words. 19 April 2018. [ONLINE] Available at: <https://www.theguardian.com/lifeands>

- ty/2018/apr/19/france-vegetarian-foods-no-meat-words
- 14 Wellesley, L. and Froggatt, A. (2015) Changing climates, changing diets: Pathways to lower meat consumption. Chatham House, 24 November 2015. [ONLINE] Available at: <https://www.chathamhouse.org/publication/chan-ging-climate-changing-diets>
- 15 Reiter, E. (2014) Making fast food: From the frying pan into the fryer. Montreal: McGill-Queen's University Press.
- 16 The Economist (2014) Eat Your Greens. [ONLINE] Available at: <http://www.economist.com/news/international/21594348-lot-can-be-done-make-meat-eating-less-bad-planet-meat-and-greens>
- 17 Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., & de Haan, C. (2006) Livestock's long shadow: Environmental issues and options (rep.). Food and Agriculture Organisation of the United Nations.
- 18 Reiter, E. (2014) Making fast food: From the frying pan into the fryer. Montreal: McGill-Queen's University Press.
- 19 O'Neill, J. et al. (2015) Antimicrobials in Agriculture and the Environment: Reducing Unnecessary Use and Waste. The Review on Antimicrobial Resistance. Available at: <https://amr-review.org/sites/default/files/Antimicrobials%20in%20agriculture%20and%20the%20environment%20-%20Reducing%20unnecessary%20use%20and%20waste.pdf>
- 20 Robinson, T. P. et al. (2011) Global livestock production systems. Food and Agriculture Organization of the United Nations (FAO) and International Livestock Research Institute (ILRI).
- 21 Robinson, T. P. et al (2011) Global livestock production systems. Food and Agriculture Organization of the United Nations (FAO) and International Livestock Research Institute (ILRI).
- 22 Friends of the Earth (2010) Briefing: Factory farming's hidden impacts [ONLINE] Available at: [https://www.foe.co.uk/sites/default/files/downloads/factory\\_farming.pdf](https://www.foe.co.uk/sites/default/files/downloads/factory_farming.pdf)
- 23 Food and Agriculture Organisation of the United Nations (2018) Food outlook: Biannual report on global food markets. [ONLINE] Available at: <http://www.fao.org/3/ca0239en/CA0239EN.pdf>
- 24 Food and Agriculture Organisation of the United Nations (2018) Food outlook: Biannual report on global food markets. [ONLINE] Available at: <http://www.fao.org/3/ca0239en/CA0239EN.pdf>
- 25 Food and Agriculture Organisation of the United Nations (2018) Food Outlook: Biannual report on global food markets. [ONLINE] Available at: <http://www.fao.org/3/ca0239en/CA0239EN.pdf>
- 26 United States Census Bureau. (2018) US and World Population Clock [ONLINE] Available at: <http://www.census.gov/popclock/>
- 27 Food and Agriculture Organisation of the United Nations. FAOSTAT [ONLINE] Available at: <http://www.fao.org/faostat/en/#data/QA>
- 28 WWF (2016) Living planet report 2016: Risk and resilience in a new era [ONLINE] Available at: <https://www.worldwildlife.org/pages/living-planet-report-2016>
- 29 BBC (n.d.) On this day 1950-2005: 4 July: Housewives celebrate end of rationing. BBC News [ONLINE] Available at: [http://news.bbc.co.uk/onthisday/hi/dates/stories/july/4/newsid\\_3818000/3818563.stm](http://news.bbc.co.uk/onthisday/hi/dates/stories/july/4/newsid_3818000/3818563.stm)
- 30 Simon, D. R. (2013) Meatonomics: How the rigged economics of meat and dairy make you consume too much and how to eat better, live longer, and spend smarter. Conari Press.
- 31 Simon, D. R. (2013) Meatonomics: How the rigged economics of meat and dairy make you consume too much and how to eat better, live longer, and spend smarter. Conari Press.
- 32 Simon, D. R. (2013) Meatonomics: how the rigged economics of meat and dairy make you consume too much and how to eat better, live longer, and spend smarter. Conari Press.
- 33 Simon, D. R. (2013) Meatonomics: How the rigged economics of meat and dairy make you consume too much and how to eat better, live longer, and spend smarter. Conari Press.
- 34 Sans, P. and Combris, P. (2015) World meat consumption patterns: An overview of the last fifty years (1961-2011). Meat Science, 109: 106-111.
- 35 Based on carcass weight, not accounting for retail losses. Organisation for Economic Co-operation and Development (2018) Meat consumption [ONLINE] Available at: <https://data.oecd.org/agroutput/meat-consumption.htm>
- 36 International Agency for Research on Cancer (2015) IARC monographs evaluate the consumption of red meat and processed meat. [ONLINE] Available at: [https://www.iarc.fr/en/media-centre/pr/2015/pdfs/pr240\\_E.pdf](https://www.iarc.fr/en/media-centre/pr/2015/pdfs/pr240_E.pdf).
- 37 Based on carcass weight, not accounting for retail losses. Organisation for Economic Co-operation and Development (2018) Meat consumption [ONLINE] Available at: <https://data.oecd.org/agroutput/meat-consumption.htm>
- 38 Based on carcass weight, not accounting for retail losses. Organisation for Economic Co-operation and Development (2018) Meat consumption [online] Available at <https://data.oecd.org/agroutput/meat-consumption.htm>
- 39 Food and Agriculture Organisation of the United Nations. FAOSTAT [online] Available at: <http://www.fao.org/faostat/en/#data/QA>
- 40 Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. and de Haan, C. (2006). Livestock's long shadow: Environmental issues and options (rep.). Food and Agriculture Organisation of the United Nations.
- 41 Food and Agriculture Organization of the United Nations (n.d.) Chapter 2: Global dairy sector: status and trends [ONLINE] Available at: <http://www.fao.org/docrep/012/i1522e/i1522e02.pdf>
- 42 International Egg Commission (2013) Atlas of the global egg industry [ONLINE] Available at: [http://www.internationalegg.com/wp-content/uploads/2015/08/atlas\\_2013\\_web.pdf](http://www.internationalegg.com/wp-content/uploads/2015/08/atlas_2013_web.pdf)
- 43 Thornton, P. et al. (2010) Livestock production: Recent trends, future prospects. Philosophical Transactions of the Royal Society B, 365: 2853-2867.
- 44 Evans, S. (2014) Why fossil fuel divestment won't be easy. Carbon Brief [ONLINE] Available at: <https://www.carbonbrief.org/why-fossil-fuel-divestment-wont-be-easy>
- 45 Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., & de Haan, C. (2006) Livestock's long shadow: Environmental issues and options (rep.) Food and Agriculture Organisation of the United Nations.
- 46 Food Planet Health (2017) Achieving the sustainable development goals through food: A cheat sheet. [ONLINE] Available at: <https://foodplanethealth.org/news/achieving-the-sustainable-development-goals-through-food-a-cheat-sheet/>
- 47 Deutsche Welle (2018) Germany's farmers still waiting for drought-aid decision. [ONLINE] Available at: <https://www.dw.com/en/germanys-farmers-still-waiting-for-drought-aid-decision/a-45069512>
- 48 Dupeux, B. (2018) Europe's farmers are lurching from crisis to crisis - we need to rebuild the system. Meta Magazine. [ONLINE] Available at: <https://metamag.org/2018/08/24/europes-farmers-are-lurching-from-crisis-to-crisis-we-need-to-rebuild-the-system/>
- 49 McMahon, J. (2016) Paris Agreement portends a reckoning for meat and dairy. Forbes, 1 January 2016 [ONLINE] Available at: <http://www.forbes.com/sites/jeffmcMahon/2016/01/01/paris-agreement-will-impact-meat-and->

- dairy/#2e0c699b696d
- 50 Food and Agriculture Organisation of the United Nations (2018) GLEAM 2.0: Assessment of greenhouse gas emissions and mitigation potential. [ONLINE] Available at: <http://www.fao.org/gleam/results/en/>
- 51 Bailey, R., Froggatt, A. and Wellesley, L. (2014). Livestock: Climate change's forgotten sector: global public opinion on meat and dairy consumption. Chatham House.
- 52 Gerber, P. J. et al. (2013) Tackling climate change through livestock: A global assessment of emissions and mitigation opportunities. Food and Agriculture Organisation of the United Nations.
- 53 Food and Agriculture Organisation of the United Nations. Sources of meat [ONLINE] Available at: [http://www.fao.org/ag/againfo/themes/en/meat/backgr\\_sources.html](http://www.fao.org/ag/againfo/themes/en/meat/backgr_sources.html)
- 54 Tubiello, F. N. et al. (2014) The contribution of agriculture, forestry and other land use activities to global warming, 1990–2012. *Global Change Biology*. [ONLINE] Available at: <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.12865>
- 55 Food and Agriculture Organisation of the United Nations (2018) GLEAM 2.0: Assessment of greenhouse gas emissions and mitigation potential. [ONLINE] Available at: <http://www.fao.org/gleam/results/en/>
- 56 Ranganathan, J. et al. (2016). Shifting diets for a sustainable food future. World Resources Institute.
- 57 World Resources Institute (2013) Creating a sustainable food future : A menu of solutions to sustainably feed more than 9 billion people by 2050. World Resources Report, 2013–14: 130.
- 58 Bajželj, B. et al. (2014). Importance of food-demand management for climate mitigation. *Nature Climate Change*, 4(10): 924–929.
- 59 European Commission. Paris Agreement [ONLINE] Available at: [http://ec.europa.eu/clima/policies/international/negotiations/paris/index\\_en.htm](http://ec.europa.eu/clima/policies/international/negotiations/paris/index_en.htm)
- 60 Climate Action Tracker (2014) CAT's Bonn policy update [ONLINE]. Available at: [http://climateactiontracker.org/assets/publications/briefing\\_papers/CAT\\_Bonn\\_policy\\_update\\_jun2014-final\\_revised.pdf](http://climateactiontracker.org/assets/publications/briefing_papers/CAT_Bonn_policy_update_jun2014-final_revised.pdf)
- 61 Climate Action Tracker (2014) CAT's Bonn policy update [ONLINE]. Available at: [http://climateactiontracker.org/assets/publications/briefing\\_papers/CAT\\_Bonn\\_policy\\_update\\_jun2014-final\\_revised.pdf](http://climateactiontracker.org/assets/publications/briefing_papers/CAT_Bonn_policy_update_jun2014-final_revised.pdf)
- 62 Blackstock, J. and Allen, R. M. (2012) The science and policy of short-lived climate pollutants. Oxford Martin Policy Brief. [ONLINE] Available at: <https://www.oxfordmartin.ox.ac.uk/downloads/briefings/PolicyNote-SLCPs.pdf>
- 63 Allen, R. M. (2015) Short-lived promise? The science and policy of cumulative and short-lived climate pollutants. Oxford Martin School. [ONLINE] Available at: [https://www.oxfordmartin.ox.ac.uk/downloads/briefings/Short\\_Lived\\_Promise.pdf](https://www.oxfordmartin.ox.ac.uk/downloads/briefings/Short_Lived_Promise.pdf)
- 64 Allen, R.M. et al. (2018) A solution to the misrepresentations of CO<sub>2</sub>-equivalent emissions of short-lived climate pollutants under ambitious mitigation. *Climate and Atmospheric Science*, 1(16) [ONLINE] Available at: <https://www.nature.com/articles/s41612-018-0026-8>
- 65 Foley, J. A. et al. (2011) Solutions for a cultivated planet. *Nature*, 478: 337–342.
- 66 Gerber, P. (2007) Livestock's long shadow environmental issues and options. Presentation at Methane to Markets Partnership Expo. [ONLINE] Available at: [https://www.globalmethane.org/expo-docs/china07/postexpo/ag\\_gerber.pdf](https://www.globalmethane.org/expo-docs/china07/postexpo/ag_gerber.pdf)
- 67 Foley, J. A. et al. (2011) Solutions for a cultivated planet. *Nature*, 478: 337–342.
- 68 WWF (2017) Appetite for destruction. [ONLINE] Available at: <https://www.wwf.org.uk/updates/appetite-for-destruction>
- 69 Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. and de Haan, C. (2006) Livestock's long shadow: Environmental issues and options (rep.) Food and Agriculture Organisation of the United Nations.
- 70 Kato, E. and Yamagata, Y. (2014) BECCS capability of dedicated bioenergy crops under a future land-use scenario targeting net negative carbon emissions. *Earth's Future*, 2(9): 421–439.
- 71 Smith, P. et al. (2016) Biophysical and economic limits to negative CO<sub>2</sub> emissions. *Nature Climate Change*, 6(1): 42–50.
- 72 Rogelj, J. et al. (2015) Zero emission targets as long-term global goals for climate protection. *Environmental Research Letters*, 10.
- 73 Stehfest, E. et al. (2009) Climate benefits of changing diet. *Climatic Change*, 95(1–2): 83–102.
- 74 European Council (2017) Provisional deal on effort-sharing emissions: Another step towards Paris targets. [ONLINE] Available at: <http://www.consilium.europa.eu/en/press/press-releases/2017/12/21/provisional-deal-on-effort-sharing-emissions-another-big-step-towards-paris-targets/>
- 75 Climate Action Network Europe (2017) Statement on behalf of Climate Action Network Europe, Carbon Market Watch, European Environmental Bureau, Sandbag, Transport & Environment, and WWF European Policy Office. [ONLINE] Available at: <http://www.caneurope.org/docman/effort-sharing-decision/3260-joint-ngo-statement-the-effort-sharing-regulation/file>
- 76 Tamma, P. (2017) Member states give themselves more time to cut emissions. EURACTIV, 21 December 2017. [ONLINE] Available at: <https://www.euractiv.com/section/climate-environment/news/member-states-give-themselves-more-time-to-cut-emissions-from-transport-buildings-farming-and-waste-sectors/>
- 77 Bailey, R., Froggatt, A. and Wellesley, L. (2014) Livestock: Climate change's forgotten sector: Global public opinion on meat and dairy consumption. Chatham House [ONLINE] Available at: [https://www.chathamhouse.org/sites/default/files/field/field\\_document/20141203Livestock-ClimateChangeForgottenSectorBaileyFroggattWellesley-Final.pdf](https://www.chathamhouse.org/sites/default/files/field/field_document/20141203Livestock-ClimateChangeForgottenSectorBaileyFroggattWellesley-Final.pdf)
- 78 National Farmers Union (2015) The dairy roadmap [ONLINE] Available at: <http://www.nfuonline.com/sectors/dairy/dairy-news/the-dairy-roadmap/>
- 79 Harris, L. (2018) No progress on reducing agricultural emissions, says report. *Farmers' Weekly*, 30 January 2018. [ONLINE]. Available at: <http://www.fwi.co.uk/news/no-progress-on-reducing-agricultural-emissions-says-report.htm>
- 80 Gerber, P. J. et al (2013) Tackling climate change through livestock: A global assessment of emissions and mitigation opportunities. Food and Agriculture Organisation of the United Nations.
- 81 Gifford, D. (n/d) Grass-fed beef can help solve climate change. Small Footprint Family [ONLINE] Available at: <https://www.smallfootprintfamily.com/grass-fed-beef-and-global-warming>
- 82 Young, R. (2014) The fat of the land: Eating red meat. Sustainable Food Trust. [ONLINE] Available at: <https://sustainablefoodtrust.org/articles/red-meat/>
- 83 Garnett, T. et al. (2018) Grazed and confused. Food Climate Research Network [ONLINE] Available at: <https://www.fcrn.org.uk/projects/grazed-and-confused>
- 84 Garnett, T. et al. (2018) Grazed and confused. Food Climate Research Network [ONLINE] Available at: <https://www.fcrn.org.uk/projects/grazed-and-confused>
- 85 Garnett, T. et al. (2018) Grazed and confused. Food Cli-

- mate Research Network [ONLINE] Available at: <https://www.fcrn.org/projects/grazed-and-confused>
- 86 Ranganathan, J. et al. (2016) Shifting diets for a sustainable food future. World Resources Institute.
- 87 Bajželj, B. et al. (2014) Importance of food-demand management for climate mitigation. *Nature Climate Change*, 4(10): 924–929.
- 88 Bryngelsson, D. et al. (2016) How can the EU climate targets be met? A combined analysis of technological and demand-side changes in food and agriculture. *Food Policy*, 59: 152–164.
- 89 Poore, J. and Nemecek, T. (2018) Reducing food's environmental impacts through producers and consumers. *Science*, 360(6392): 987–992 [ONLINE] Available at: <http://science.sciencemag.org/content/360/6392/987>
- 90 Hallström, E., Carlsson-Kanyama, A. and Börjesson, P. (2015) Environmental impact of dietary change: A systematic review. *Journal of Cleaner Production*, 91: 1–11.
- 91 Heller, M. C. and Keoleian, G.A. (2015) Greenhouse gas emission estimates of US dietary choices and food loss. *Journal of Industrial Ecology*, 19(3): 391–401.
- 92 Scarborough, P., Allender, S., Clarke, D., Wickramasinghe, K. and Rayner, M. (2012) Modelling the health impact of environmentally sustainable dietary scenarios in the UK. *European Journal of Clinical Nutrition*, 66(6): 710–715.
- 93 Wynes, S. et al. (2017) The climate mitigation gap: education and government recommendations miss the most effective individual actions. *Environmental Research Letters*, 12(7). [ONLINE] Available at: <http://iopscience.iop.org/article/10.1088/1748-9326/aa7541>
- 94 Jones, C.M. and Kammen, D.M. (2011) Quantifying carbon footprint reduction opportunities for US households and communities. *Environmental Science & Technology*, 45(9): 4088–4095.
- 95 UK Department for Energy and Climate Change (2015) Prosperous living for the world in 2015: Insights from the global calculator [ONLINE] Available at: [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/398596/Global\\_calc\\_report\\_WEB.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/398596/Global_calc_report_WEB.pdf)
- 96 McMichael, A. J. et al. (2007) Food, livestock production, energy, climate change, and health [ONLINE] *The Lancet*, 370(9594): 1253–1263. Available at: [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(07\)61256-2/fulltext](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(07)61256-2/fulltext)
- 97 Tirado, R., Thompson, K. F., Miller, K. A. and Johnston, P. (2018) Less is more: Reducing meat and dairy FOR a healthier life and planet. Greenpeace Research Laboratories Technical Report [Online]. Available at: <https://www.greenpeace.org/international/publication/15093/less-is-more/>
- 98 Garnett, T. (2014) What is a sustainable healthy diet? A discussion paper. Food Climate Research Network. [ONLINE] Available at: [https://www.fcrn.org.uk/sites/default/files/fcrn\\_what\\_is\\_a\\_sustainable\\_healthy\\_diet\\_final.pdf](https://www.fcrn.org.uk/sites/default/files/fcrn_what_is_a_sustainable_healthy_diet_final.pdf)
- 99 Food and Agriculture Organisation of the United Nations (2018) Food Loss and Food Waste. [ONLINE] Available at: <http://www.fao.org/food-loss-and-food-waste/en/>
- 100 Lipinski, B., Hanson, C., Lomax, J., Kitinoja, L., Waite, R. and Searchinger, T. (2013) Creating a sustainable food future: Reducing food loss and Waste. World Resources Institute [ONLINE] Available at: <http://unep.org/wed/docs/WRI-UNEP-Reducing-Food-Loss-and-Waste.pdf>
- 101 Food and Agriculture Organisation of the United Nations (2014) Food wastage footprint: Full-cost accounting [ONLINE] Available at: <http://www.fao.org/publications/card/en/c/5e7c4154-2b97-4ea5-83a7-be9604925a24/>
- 102 Fairlie, S. (2010) Meat: A benign extravagance. Permanent Publications.
- 103 Thornton, P. K. (2010) Livestock production: Recent trends, future prospects. *Philosophical Transactions of the Royal Society of Biological Sciences*, 365(1554): 2853–2867.
- 104 Machovina, B., Feeley, K. J. and Ripple, W. J. (2015) Biodiversity conservation: The key is reducing meat consumption. *Science of the Total Environment*, 536: 419–431.
- 105 Pimm, S. et al. (2014) The biodiversity of species and their rates of extinction, distribution, and protection. *Science*, 344(6187)
- 106 WWF (2014) Living Planet Report 2014: Species and spaces, people and places. [ONLINE] Available at: [https://www.wwf.or.jp/activities/data/WWF\\_LPR\\_2014.pdf](https://www.wwf.or.jp/activities/data/WWF_LPR_2014.pdf)
- 107 WWF (2015) Living Blue Planet Report. Species, habitats and human well-being. [ONLINE] Available at: <https://www.worldwildlife.org/publications/living-blue-planet-report-2015>
- 108 Machovina, B., Feeley, K. J. and Ripple, W. J. (2015) Biodiversity conservation: The key is reducing meat consumption. *Science of The Total Environment*, 536: 419–431.
- 109 Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. and de Haan, C. (2006) Livestock's long shadow: Environmental issues and options (rep.). Food and Agriculture Organization of the United Nations.
- 110 Smithers, R. (2017) Vast animal-feed crops to satisfy our meat needs are destroying planet. *The Guardian*, 5 October 2017. [ONLINE] Available at: <https://www.theguardian.com/environment/2017/oct/05/vast-animal-feed-crops-meat-needs-destroying-planet>
- 111 Food and Agriculture Organisation of the United Nations. Sources of meat. [ONLINE] Available at: [http://www.fao.org/ag/againfo/themes/en/meat/backgr\\_sources.html](http://www.fao.org/ag/againfo/themes/en/meat/backgr_sources.html)
- 112 Smil, V. (2013) Harvesting the biosphere: What we have taken from nature. Massachusetts Institute of Technology.
- 113 Foley, J. A. et al. (2011) Solutions for a cultivated planet. *Nature*, 478: 337–342.
- 114 Venter, O. et al. (2014) Targeting global protected area expansion for imperiled biodiversity. *PLoS Biology*, 12(6).
- 115 Tilman, D., Balzer, C., Hill, J. and Befort, B. L. (2011) Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences*, 108(50): 20260–20264.
- 116 Machovina, B., Feeley, K. J. and Ripple, W. J. (2015) Biodiversity conservation: The key is reducing meat consumption. *Science of the Total Environment*, 536: 419–431.
- 117 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.
- 118 European Commission (2013) The impact of EU consumption on deforestation : Comprehensive analysis of the impact of EU consumption on deforestation [ONLINE] Available at: <http://ec.europa.eu/environment/forests/pdf/1.%20Report%20analysis%20of%20impact.pdf>
- 119 Sandilyan, S. and Kathiresan, K. (2012) Mangrove conservation: A global perspective. *Biodiversity and Conservation*, 21(14): 3523–3542.
- 120 Van Asselen, S., Verburg, P. H., Vermaat, J. E. and Janse, J. H. (2013) Drivers of wetland conversion: A global meta-analysis. *PloS One*, 8(11).
- 121 Smithers, R. (2017) Vast animal-feed crops to satisfy our meat needs are destroying planet. *The Guardian*, 5 October 2017. [ONLINE] Available at: <https://www.theguardian.com/environment/2017/oct/05/vast-animal-feed-crops-meat-needs-destroying-planet>
- 122 Gibbs, H.K. et al. (2010). Tropical forests were the pri-

- mary sources of new agricultural in the 1980s and 1990s. Proceedings of the National Academy of Sciences, 107(38): 16732–16737.
- 123 Kastner, T., Rivas, M. J. I., Koch, W. and Nonhebel, S. (2012) Global changes in diets and the consequences for land requirements for food. Proceedings of the National Academy of Sciences, 109(18): 6868–6872.
- 124 Bajželj, B. et al. (2014) Importance of food-demand management for climate mitigation. *Nature Climate Change*, 4(10): 924–929.
- 125 Erb, K. H. et al. (2016) Exploring the biophysical option space for feeding the world without deforestation. *Nature Communications*, 7.
- 126 Tuck, S. L. et al. (2014) Land-use intensity and the effects of organic farming on biodiversity: A hierarchical meta-analysis. *Journal of Applied Ecology*, 51(3): 746–755.
- 127 Hosonuma, N. et al. (2012) An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letters*, 7(4)
- 128 European Commission (2013) The impact of EU consumption on deforestation : Comprehensive analysis of the impact of EU consumption on deforestation. [Online] Available at: <http://ec.europa.eu/environment/forests/pdf/1.%20Report%20analysis%20of%20impact.pdf>
- 129 WWF (2014) The growth of soy: Impacts and solutions [ONLINE] Available at: [http://awsassets.wwfkd.panda.org/downloads/wwf\\_soy\\_report\\_final\\_jan\\_19.pdf](http://awsassets.wwfkd.panda.org/downloads/wwf_soy_report_final_jan_19.pdf)
- 130 Persson, M., Henders, S. and Kastner, T. (2014) Trading forests: Quantifying the contribution of global commodity markets to emissions from tropical deforestation. Centre for Global Development.
- 131 European Commission (2013) The impact of EU consumption on deforestation: Comprehensive analysis of the impact of EU consumption on deforestation [ONLINE] Available at: <http://ec.europa.eu/environment/forests/pdf/1.%20Report%20analysis%20of%20impact.pdf>
- 132 Kroes, H. and Kuepper, B. (2015) Mapping the soy supply chain in Europe: A research paper prepared for WNF. Profundo [ONLINE] Available at: [http://assets.wnf.nl/downloads/mapping\\_the\\_soy\\_supply\\_chain\\_in\\_europe\\_wnf\\_12\\_may\\_2015\\_final\\_1.pdf](http://assets.wnf.nl/downloads/mapping_the_soy_supply_chain_in_europe_wnf_12_may_2015_final_1.pdf)
- 133 WWF (2014) The growth of soy: Impacts and solutions [ONLINE] Available at: [http://awsassets.wwfkd.panda.org/downloads/wwf\\_soy\\_report\\_final\\_jan\\_19.pdf](http://awsassets.wwfkd.panda.org/downloads/wwf_soy_report_final_jan_19.pdf)
- 134 Kroes, H. and Kuepper, B. (2015) Mapping the soy supply chain in Europe: A research paper prepared for WNF. Profundo [ONLINE] Available at: [http://assets.wnf.nl/downloads/mapping\\_the\\_soy\\_supply\\_chain\\_in\\_europe\\_wnf\\_12\\_may\\_2015\\_final\\_1.pdf](http://assets.wnf.nl/downloads/mapping_the_soy_supply_chain_in_europe_wnf_12_may_2015_final_1.pdf)
- 135 Kroes, H. and Kuepper, B. (2015) Mapping the soy supply chain in Europe: A research paper prepared for WNF. Profundo [Online] Available at: [http://assets.wnf.nl/downloads/mapping\\_the\\_soy\\_supply\\_chain\\_in\\_europe\\_wnf\\_12\\_may\\_2015\\_final\\_1.pdf](http://assets.wnf.nl/downloads/mapping_the_soy_supply_chain_in_europe_wnf_12_may_2015_final_1.pdf)
- 136 WWF (2014) The growth of soy: Impacts and solutions [ONLINE] Available at: [http://awsassets.wwfkd.panda.org/downloads/wwf\\_soy\\_report\\_final\\_jan\\_19.pdf](http://awsassets.wwfkd.panda.org/downloads/wwf_soy_report_final_jan_19.pdf)
- 137 Powell, T. W. and Lenton, T.M. (2013) Scenarios for future biodiversity loss due to multiple drivers reveal conflict between mitigating climate change and preserving biodiversity. *Environmental Research Letters*, 8(2): 025024
- 138 Ripple, W.J. et al. (2015) Collapse of the world's largest herbivores. *Science Advances*, 1(4).
- 139 Krausmann, F. et al. (2008) Global patterns of socioeconomic biomass flows in the year 2000: A comprehensive assessment of supply, consumption and constraints. *Ecological Economics*, 65(3): 471–487.
- 140 Alder, J., Campbell, B., Karpouzi, V., Kaschner, K. and Pauly, D. (2008) Forage fish: From ecosystems to markets. *Annual Review of Environment and Resources*, 33(1): 153.
- 141 Food and Agriculture Organization of the United Nations (2016). The state of world fisheries and aquaculture. [ONLINE] Available at: <http://www.fao.org/3/a-i5555e.pdf>
- 142 Shepherd, C. J. and Jackson, A. J. (2013) Global fishmeal and fish-oil supply: Inputs, outputs and markets. *Journal of Fish Biology*, 83(4): 1046–1066.
- 143 Tacon, A. G. and Metian, M. (2015) Feed matters: Satisfying the feed demand of aquaculture. *Reviews in Fisheries Science & Aquaculture*, 23(1): 1–10.
- 144 Shepherd, C. J. and Jackson, A. J. (2013) Global fishmeal and fish-oil supply: Inputs, outputs and markets. *Journal of Fish Biology*, 83: 1046–1066.
- 145 Ripple, W. J. et al. (2014) Status and ecological effects of the world's largest carnivores. *Science*, 343(6167)
- 146 Carreira, D., Re'em, A. and Miriam, T. (2015) Natural capital risk exposure of the financial sector in Brazil. TruCost. [ONLINE] Available at: <https://www.trucost.com/publication/natural-capital-risk-exposure-financial-sector-brazil-full-report/>
- 147 Graesser, J., Aide, T. M., Grau, H. R. and Ramankutty, N. (2015) Cropland/pastureland dynamics and the slowdown of deforestation in Latin America. *Environmental Research Letters*.
- 148 Persson, M., Henders, S. and Kastner, T. Trading (2014) Forests: Quantifying the contribution of global commodity markets to emissions from tropical deforestation. *Cent. Glob. Dev.*
- 149 Hosonuma, N. et al. (2012) An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letters*, 7, 044009.
- 150 Persson, M., Henders, S. and Kastner, T. (2014) Forests: Quantifying the contribution of global commodity markets to emissions from tropical deforestation. *Cent. Glob. Dev.*
- 151 Food and Agriculture Organisation of the United Nations (2018) Food outlook: Biannual report on global food markets. [Online] Available at: <http://www.fao.org/3/ca0239en/CA0239EN.pdf>
- 152 Walker, N., Patel, S. and Kalif, K. (2013) From Amazon pasture to the high street: Deforestation and the Brazilian cattle product supply chain. *Tropical Conservation Science*, 6: 446–467.
- 153 Walker, N., Patel, S. and Kalif, K. (2013) From Amazon pasture to the high street: Deforestation and the Brazilian cattle product supply chain. *Tropical Conservation Science*, 6: 446–467.
- 154 Walsh, B. (2013) The triple whopper environmental impact of global meat production. *Time*, 16 December 2013. [ONLINE] Available at: <http://science.time.com/2013/12/16/the-triple-whopper-environmental-impact-of-global-meat-production/>
- 155 Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. and de Haan, C. (2006). Livestock's long shadow: Environmental issues and options (rep.). Food and Agriculture Organisation of the United Nations.
- 156 Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., and de Haan, C. (2006). Livestock's long shadow: Environmental issues and options (rep.). Food and Agriculture Organisation of the United Nations.
- 157 Compassion in World Farming (2016) Cheap food costs dear. [ONLINE] Available at: <https://www.ciwf.org.uk/media/7426410/cheap-food-costs-dear.pdf>
- 158 Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. and de Haan, C. (2006). Livestock's long shadow: Environmental issues and options (rep.). Food and Agriculture Organisation of the United Nations.



- 159 Gerber, P. J. et al. (2014) Nutrient use efficiency: A valuable approach to benchmark the sustainability of nutrient use in global livestock production? *Current Opinion in Environmental Sustainability*, 9: 122-130.
- 160 Leip, A., Weiss, F., Lesschen, J. P. and Westhoek, H. (2014) The nitrogen footprint of food products in the European Union. *The Journal of Agricultural Science*, 152(S1): 20-33.
- 161 Metson, G. S., Bennett, E. M. and Elser, J. J. (2012) The role of diet in phosphorus demand. *Environmental Research Letters*, 7(4): 044043.
- 162 Sutton, M. A. et al. (2011) Too much of a good thing. *Nature*, 472(7342): 159-161.
- 163 Steffen, W. et al. (2015) Planetary boundaries: Guiding human development on a changing planet. *Science Magazine*.
- 164 Sutton, M. A. et al. (2011) Too much of a good thing. *Nature*, 472(7342): 159-161.
- 165 Wellesley, L., Happer, C. and Froggatt, A. (2015) Changing climate, changing diets: Pathways to lower meat consumption. Chatham House [ONLINE] Available at: [https://www.chathamhouse.org/sites/default/files/publications/research/CHHJ3820%20Diet%20and%20climate%20change%2018.11.15\\_WEB\\_NEW.pdf](https://www.chathamhouse.org/sites/default/files/publications/research/CHHJ3820%20Diet%20and%20climate%20change%2018.11.15_WEB_NEW.pdf)
- 166 International Agency for Research on Cancer (2015) Monographs evaluate the consumption of red meat and processed meat [ONLINE] Available at: [https://www.iarc.fr/en/media-centre/pr/2015/pdfs/pr240\\_E.pdf](https://www.iarc.fr/en/media-centre/pr/2015/pdfs/pr240_E.pdf).
- 167 British Nutrition Foundation (2016) Healthy eating for vegans and vegetarians [ONLINE] Available at: <https://www.nutrition.org.uk/healthyliving/healthyeating/vegan-and-vegetarian.html>.
- 168 Diabetes UK (2014) Treating diabetes costs GBP 10bn each year to the UK National Health Service. *The Cost of Diabetes* [ONLINE] Available at: <https://www.diabetes.org.uk/Documents/Diabetes%20UK%20Cost%20of%20Diabetes%20Report.pdf>
- 169 International Agency for Research on Cancer (2015) IARC monographs evaluate the consumption of red meat and processed meat [ONLINE] Available at: [https://www.iarc.fr/en/media-centre/pr/2015/pdfs/pr240\\_E.pdf](https://www.iarc.fr/en/media-centre/pr/2015/pdfs/pr240_E.pdf).
- 170 Willett, W. (2001) *Eat, drink, and be healthy: The Harvard Medical School Guide to Healthy Eating*. Free Press.
- 171 Wellesley, L., Happer, C. and Froggatt, A. (2015) Changing climate, changing diets: Pathways to lower meat consumption. Chatham House [ONLINE] Available at: [https://www.chathamhouse.org/sites/default/files/publications/research/CHHJ3820%20Diet%20and%20climate%20change%2018.11.15\\_WEB\\_NEW.pdf](https://www.chathamhouse.org/sites/default/files/publications/research/CHHJ3820%20Diet%20and%20climate%20change%2018.11.15_WEB_NEW.pdf)
- 172 Shapiro, P. (2018) Clean meat: How growing meat without animals will revolutionise dinner and the world. *Gallery Books*: 173.
- 173 Compassion in World Farming (2016) Cheap food costs dear [ONLINE] Available at: <https://www.ciwf.org.uk/media/7426410/cheap-food-costs-dear.pdf>
- 174 International Agency for Research on Cancer (2015) Monographs evaluate the consumption of red meat and processed meat [ONLINE] Available at: [https://www.iarc.fr/en/media-centre/pr/2015/pdfs/pr240\\_E.pdf](https://www.iarc.fr/en/media-centre/pr/2015/pdfs/pr240_E.pdf).
- 175 Gani, A. (2015) UK shoppers give pork the chop after processed meats linked to cancer. *The Guardian*, 23 November 2005 [ONLINE] Available at: <https://www.theguardian.com/uk-news/2015/nov/23/bacon-sausage-sales-fall-who-report-cancer-risk-processed-meat>
- 176 Cancer Research UK (n.d.) Your cancer type [ONLINE] Available at: <http://www.cancerresearchuk.org/about-cancer/type/>
- 177 Cancer Research UK (n.d.) Your cancer type [ONLINE] Available at: <http://www.cancerresearchuk.org/about-cancer/type/>
- 178 O'Neill, J. et al. (2015) Antimicrobials in agriculture and the environment: Reducing unnecessary use and waste. London: The Review on Antimicrobial Resistance. [ONLINE] Available at: <https://amr-review.org/sites/default/files/Antimicrobials%20in%20agriculture%20and%20the%20environment%20-%20Reducing%20unnecessary%20use%20and%20waste.pdf>
- 179 O'Neill, J. et al. (2015) Antimicrobials In agriculture and the environment: Reducing unnecessary use and waste. London: The Review on Antimicrobial Resistance. [ONLINE] Available at: <https://amr-review.org/sites/default/files/Antimicrobials%20in%20agriculture%20and%20the%20environment%20-%20Reducing%20unnecessary%20use%20and%20waste.pdf>
- 180 McKenna, M. (2015) Apocalypse Pig: The Last Antibiotic Begins to Fail. *National Geographic* [ONLINE] Available at: <https://www.nationalgeographic.com/science/phenomena/2015/11/21/mcr-gene-colistin/>
- 181 Compassion in World Farming (2016) Cheap food costs dear [ONLINE] Available at: <https://www.ciwf.org.uk/media/7426410/cheap-food-costs-dear.pdf>
- 182 O'Neill, J. et al. (2015) Antimicrobials in agriculture and the environment: Reducing unnecessary use and waste. London: The Review on Antimicrobial Resistance. Available at: <https://amr-review.org/sites/default/files/Antimicrobials%20in%20agriculture%20and%20the%20environment%20-%20Reducing%20unnecessary%20use%20and%20waste.pdf>
- 183 Grace Communications Foundation (2015) Industrial livestock production [ONLINE] Available at: <http://www.sustainabletable.org/859/industrial-livestock-production>.
- 184 US Environmental Protection Agency (2008) Animal feeding operations [ONLINE] Available at: <https://www.epa.gov/npdes/animal-feeding-operations-afos>
- 185 Friends of the Earth (2012) Factory farming in Europe: The impacts and our demands of the Common Agricultural Policy [ONLINE] Available at: [https://www.foe.co.uk/sites/default/files/downloads/cap\\_briefing\\_2012.pdf](https://www.foe.co.uk/sites/default/files/downloads/cap_briefing_2012.pdf)
- 186 World Health Organization (n.d.) Zoonoses: Fact sheet. Available at: <http://www.wpro.who.int/vietnam/topics/zoonoses/factsheet/en/>
- 187 European Commission (2016) General Q&A: New EU Regulation on transmissible animal diseases ('Animal Health Law') March 2016 [ONLINE] Available at: [http://ec.europa.eu/food/animals/docs/ah-regulation-qanda\\_ah1\\_proposal.pdf](http://ec.europa.eu/food/animals/docs/ah-regulation-qanda_ah1_proposal.pdf)
- 188 Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. and de Haan, C. (2006) *Livestock's long shadow: Environmental issues and options (rep.)*. Food and Agriculture Organisation of the United Nations.
- 189 Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. and de Haan, C. (2006) *Livestock's long shadow: Environmental issues and options (rep.)*. Food and Agriculture Organisation of the United Nations.
- 190 Friends of the Earth (2012) Factory farming in Europe: The impacts and our demands of the common agricultural policy [ONLINE] Available at: [https://www.foe.co.uk/sites/default/files/downloads/cap\\_briefing\\_2012.pdf](https://www.foe.co.uk/sites/default/files/downloads/cap_briefing_2012.pdf)
- 191 Food and Agriculture Organisation of the United Nations (2018). FAOSTAT. [ONLINE] Available at: <http://www.fao.org/faostat/en/#data/QL> [Accessed 24 Aug. 2018].
- 192 European Union (2012) Consolidated version of the Treaty on the Functioning of the European Union, 26 October 2012, 2012/C, 326/54. [ONLINE] Available at: <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012E/TXT&from=EN>
- 193 Veganuary (2018). Veganuary 2018: The results are in! [ONLINE] Available at: <https://veganuary.com/blog/veganuary-2018-the-results-are-in/>
- 194 European Commission (2018) Public opinion. [ONLINE] Available at: <http://ec.europa.eu/COMMFrontOffice/>

- publicopinion/index.cfm/Survey/getSurveyDetail/instruments/SPECIAL/surveyKy/2096
- 195 Sentience Institute (2018). Animal farming attitudes survey 2017. [ONLINE] Available at: <https://www.sentienceinstitute.org/animal-farming-attitudes-survey-2017> [Accessed 24 Aug. 2018].
- 196 Harari, Y. (2015). Industrial farming is one of the worst crimes in history. The Guardian, 25 September 2015. [ONLINE] Available at: <https://www.theguardian.com/books/2015/sep/25/industrial-farming-one-worst-crimes-history-ethical-question> [Accessed 24 Aug. 2018].
- 197 GRAIN and IATP (2018) Emissions impossible: How big meat and dairy are heating up the planet. [ONLINE] Available at: <https://www.grain.org/article/entries/5976-emissions-impossible-how-big-meat-and-dairy-are-heating-up-the-planet>
- 198 Steinfeld, H. (2010) Livestock in a changing landscape: Volume 1. Island Press [ONLINE] Available at: <http://public.eblib.com/choice/publicfullrecord.aspx?p=3317534>
- 199 Steinfeld, H. (2010) Livestock in a changing landscape: Volume 1. Island Press [ONLINE] Available at: <http://public.eblib.com/choice/publicfullrecord.aspx?p=3317534>
- 200 Brack, D. et al. (2016) Agricultural commodity supply chains: Trade, consumption and deforestation. Chatham House [ONLINE] Available at: <https://www.chathamhouse.org/sites/default/files/publications/research/2016-01-28-agricultural-commodities-brack-glover-wellesley.pdf>
- 201 Steinfeld, H. (2010) Livestock in a changing landscape: Volume 1 Island Press. [ONLINE] Available at: <http://public.eblib.com/choice/publicfullrecord.aspx?p=3317534>
- 202 Food and Agriculture Organisation of the United Nations (2018) Food outlook: Biannual report on global food markets. [ONLINE] Available at: <http://www.fao.org/3/ca0239en/CA0239EN.pdf>
- 203 Food and Agriculture Organisation of the United Nations (2018) Food outlook: Biannual report on global food markets. [ONLINE] Available at: <http://www.fao.org/3/ca0239en/CA0239EN.pdf>
- 204 Food and Agriculture Organisation of the United Nations (2018) Food outlook: Biannual report on global food markets. [ONLINE] Available at: <http://www.fao.org/3/ca0239en/CA0239EN.pdf>
- 205 Food and Agriculture Organisation of the United Nations (2018) Food Outlook: Biannual Report on Global Food Markets. [ONLINE] Available at: <http://www.fao.org/3/ca0239en/CA0239EN.pdf>
- 206 International Egg Commission (2013) Atlas of the global egg industry [ONLINE] Available at: [http://www.internationalegg.com/wp-content/uploads/2015/08/atlas\\_2013\\_web.pdf](http://www.internationalegg.com/wp-content/uploads/2015/08/atlas_2013_web.pdf)
- 207 Brack, D. et al. (2016) Agricultural commodity supply chains: Trade, consumption and deforestation. Chatham House [ONLINE] Available at: <https://www.chathamhouse.org/sites/default/files/publications/research/2016-01-28-agricultural-commodities-brack-glover-wellesley.pdf>
- 208 Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. and de Haan, C. (2006). Livestock's long shadow: Environmental issues and options (rep.). Food and Agriculture Organisation of the United Nations.
- 209 Animal Taskforce (2017) Why is European animal production important today? Facts and figures [ONLINE] Available at: [http://www.animaltaskforce.eu/Portals/0/ATF/Downloads/Facts%20and%20figures%20sustainable%20and%20competitive%20livestock%20sector%20in%20EU\\_Final.pdf](http://www.animaltaskforce.eu/Portals/0/ATF/Downloads/Facts%20and%20figures%20sustainable%20and%20competitive%20livestock%20sector%20in%20EU_Final.pdf)
- 210 Russia Today (2015) China to build giant dairy farm to supply Russia. 29 June 2015. [ONLINE] Available at: <https://www.rt.com/business/270463-china-russia-milk-farm/>
- 211 Harrabin, R. (2013) New EU farm subsidy plan criticised by green groups. BBC, 20 March 2013. [ONLINE] Available at: <http://www.bbc.co.uk/news/world-euro-pe-21857459>
- 212 BBC (n.d.) Spending the EU budget. [ONLINE] Available at: <http://news.bbc.co.uk/1/hi/world/europe/8036096.stm#start>
- 213 The Economist (2015) Farm prices: Milking tax payers. [ONLINE] Available at: <http://www.economist.com/news/united-states/21643191-crop-prices-fall-farmers-grow-subsidies-instead-milking-taxpayers>
- 214 Ethical Consumer (2017) The NFU: An English agribusiness lobby group. [ONLINE] Available at: <http://www.ethicalconsumer.org/commentanalysis/corporatewatch/thenfureport.aspx>
- 215 National Farmers' Union (2017) Financial statements 31.10.17. [ONLINE] Available at: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/698820/245E\\_2017.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/698820/245E_2017.pdf)
- 216 European Commission (n.d.) Transparency register. [ONLINE] Available at: <http://ec.europa.eu/transparencyregister/public/consultation/displaylobbyist.do?id=961181120948-12>
- 217 Simon, D. R. (2013) Meatonomics: How the rigged economics of meat and dairy make you consume too much – and how to eat better, live longer, and spend smarter. Conari Press.
- 218 Robison, S. D. (2013) 10 things we wish everyone knew about the meat and dairy industries. PETA. [ONLINE] Available at: <http://www.peta.org/living/food/10-things-wish-everyone-knew-meat-dairy-industries/>
- 219 Simon, D.R. (2013) Meatonomics: How the rigged economics of meat and dairy make you consume too much – and how to eat better, live longer, and spend smarter. Conari Press.
- 220 Watt Global Media (n/a) The world's leading feed producers. [ONLINE] Available at: <http://www.wattagnet.com/directories/81-the-world-s-leading-feed-producers>
- 221 Charoen Pokphand Foods (2018) 1H18 briefing investors presentation. [ONLINE] Available at: [https://www.cp-worldwide.com/contents/investors/download/presentations/CPF\\_1H18\\_Results.pdf](https://www.cp-worldwide.com/contents/investors/download/presentations/CPF_1H18_Results.pdf)
- 222 Watt Global Media (n/a) The world's leading feed producers. [ONLINE] Available at: <http://www.wattagnet.com/directories/81-the-world-s-leading-feed-producers>
- 223 Cargill (n.d.) About us. [ONLINE] Available at: <https://www.cargill.com/animal-nutrition/about-us>
- 224 Cargill (2018) Cargill's annual report. [ONLINE] Available at: <https://www.cargill.com/doc/1432124831909/2018-annual-report.pdf>
- 225 Cargill (n.d.) Animal nutrition. [ONLINE] Available at: <https://www.cargill.com/animal-nutrition>
- 226 Adario, P. (2016) The soy moratorium, 10 years on: How one commitment is stopping Amazon destruction. Greenpeace. [ONLINE] Available at: <https://www.greenpeace.org/archive-international/en/news/Blogs/makingwaves/the-soy-moratorium-10-year-anniversary-stopping-amazon-destruction/blog/57127/>
- 227 Adario, P. (2016) The soy moratorium, 10 years on: How one commitment is stopping Amazon destruction. Greenpeace. [ONLINE] Available at: <https://www.greenpeace.org/archive-international/en/news/Blogs/makingwaves/the-soy-moratorium-10-year-anniversary-stopping-amazon-destruction/blog/57127/>
- 228 Spring, J. (2018) Soy boom devours Brazil's tropical savanna. Reuters. [ONLINE] Available at: <https://www.reuters.com/investigates/special-report/brazil-deforestation/>
- 229 Yousefi, A., Bellantonio, M. and Hurowitz, G. (2018) The avoidable crisis: The European meat industry's environmental catastrophe. Mighty Earth. [ONLINE] Available at: <http://www.mightyearth.org/avoidablecrisis/>
- 230 Spring, J. (2018) Soy boom devours Brazil's tropical

- savanna. Reuters. [ONLINE] Available at: <https://www.reuters.com/investigates/special-report/brazil-deforestation/>
- 231 JBS (2018) 2017 annual and sustainability report. [ONLINE] Available at: <http://jbs.fooinvest.com.br/enu/4588/JBS%20RA%20EN%20180427%20Final.pdf>
- 232 JBS (2018) 2017 annual and sustainability report. [ONLINE] Available at: <http://jbs.fooinvest.com.br/enu/4588/JBS%20RA%20EN%at%20Final.pdf>
- 233 Tyson (2018) Annual report for fiscal year 2017. [ONLINE] Available at: <http://ir.tyson.com/investor-relations/financial-reports/annual-reports/default.aspx>
- 234 The National Provisioner (2018) The 2018 Top 100 meat & poultry processors. [ONLINE] Available at: <https://www.provisioneronline.com/2018-top-100-meat-and-poultry-processors>
- 235 WH Group (2018) 2017 annual report. [ONLINE] Available at: <http://doc.irasia.com/listco/hk/whgroup/annual/2017/ar2017.pdf>
- 236 Danish Crown (2017) Annual report 2016/17. [ONLINE] Available at: <https://www.danishcrown.com/media/5171/danish-crown-annual-report-2016-17.pdf>
- 237 Tönnies (2018) Facts about Tönnies. [ONLINE] Available at: [https://www.toennies.de/fileadmin/content/documents/presse/Pressemappe\\_Englisch.pdf](https://www.toennies.de/fileadmin/content/documents/presse/Pressemappe_Englisch.pdf)
- 238 Vion (2018) Annual report 2017. [ONLINE]. Available at: <https://www.vionfoodgroup.com/app/uploads/2018/04/Vion-annual-report-2017.pdf>
- 239 LDC (n.d.) LDC in figures. [ONLINE] Available at: <https://www ldc.fr/en/rubrique/ldc-group/ldc-in-figures/>
- 240 RaboResearch (2018) Global dairy top 20: A shuffling of the deck chairs. Rabobank, 26 July 2018. [ONLINE] Available at: <https://www.rabobank.com/en/press/search/2018/20180726-global-dairy-top-20-a-shuffling-of-the-deck-chairs.html>
- 241 HM Government (2014) Elliott review into the integrity and assurance of food supply networks – final report: A national food crime prevention framework. [ONLINE] Available at: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/350726/elliott-review-final-report-july2014.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/350726/elliott-review-final-report-july2014.pdf)
- 242 Compassion in World Farming (n.d.) Award winners. [ONLINE] Available at: <https://www.compassioninfood-business.com/award-winners/>
- 243 Forbes (n.d.) The world's largest public companies list. Forbes. [ONLINE] Available at: <https://www.forbes.com/global2000/#338254ae335d>
- 244 McDonald's (n.d.) Helping lead a global movement for beef sustainability. [ONLINE] Available at: [http://www.aboutmcdonalds.com/mcd/sustainability/signature\\_programs/beef-sustainability.html](http://www.aboutmcdonalds.com/mcd/sustainability/signature_programs/beef-sustainability.html)
- 245 Lepore, M. (2011) 15 facts about Starbucks that will blow your mind. Business Insider, 25 March 2011. [ONLINE] Available at: <http://www.businessinsider.com/15-facts-about-starbucks-that-will-blow-your-mind-2011-3?IR=T>
- 246 Michaels, L. (2001) What's wrong with supermarkets? Corporate Watch [ONLINE] Available at: <https://corporatetwatch.org/content/whats-wrong-supermarkets-3-encouraging-industrial-agriculture>
- 247 Compassion in World Farming (n/a) Award winners. [ONLINE] Available at: <https://www.compassioninfood-business.com/award-winners/>
- 248 McDonald's (n.d.) Working with suppliers to protect: Animal health and welfare. [ONLINE] Available at <https://corporate.mcdonalds.com/corpmcd/scale-for-good/our-food/animal-health-and-welfare.html>
- 249 Subway (n.d.) Sustainable sourcing. [ONLINE] Available at: <http://www.subway.com/en-us/aboutus/socialresponsibility/sustainablesourcing>
- 250 Yum (n.d.) Good antimicrobial stewardship. [ONLINE] Available at: <http://www.yum.com/responsibility/food/ethical-sourcing-supply-chain/good-antimicrobial-stewardship/>
- 251 McDonald's (n/a) Helping lead a global movement for beef sustainability. [ONLINE] Available at: <https://corporate.mcdonalds.com/content/dam/gwscorp/scale-for-good/McDonald%27s-Beef-Sustainability-Report.pdf>
- 252 Hamerschlag, K. (2018) Opinion: 50 groups denounce roundtable on sustainable beef as greenwash. Foodtank. [ONLINE] Available at: <https://foodtank.com/news/2018/06/foe-opinion-sustainable-beef-roundtable-greenwash/>
- 253 The Changing Markets Foundation (2018) The false promise of certification. [ONLINE] Available at: [http://changingmarkets.org/wp-content/uploads/2018/06/THE\\_FALSE\\_PROMISE\\_OF\\_CERTIFICATION\\_FINAL\\_WEB.pdf](http://changingmarkets.org/wp-content/uploads/2018/06/THE_FALSE_PROMISE_OF_CERTIFICATION_FINAL_WEB.pdf)
- 254 Tree, I. (2018) If you want to save the world, veganism isn't the answer. The Guardian, 25 August 2018. [ONLINE] Available at: <https://www.theguardian.com/commentisfree/2018/aug/25/veganism-intensively-farmed-meat-dairy-soya-maize>
- 255 Dibb, S. and Salazar, E. (2018) Principles for eating meat and dairy more sustainably: The 'less and better' approach. Eating Better. [ONLINE] Available at: <https://www.eating-better.org/2018/04/Less-and-Better-Report.html>
- 256 Compassion in World Farming and One Kind (2012) Farm assurance schemes & animal welfare: How the standards compare. [ONLINE] Available at: [https://www.ciwf.org.uk/media/5231246/standards\\_analysis\\_exec\\_summary.pdf](https://www.ciwf.org.uk/media/5231246/standards_analysis_exec_summary.pdf)
- 257 UK Department for Environment, Food and Rural Affairs and National Statistics (2018) Organic farming statistics 2017. [ONLINE] Available at: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/707613/organics-statsnotice-17may18.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/707613/organics-statsnotice-17may18.pdf)
- 258 United States Department for Agriculture (2013) Organic production. [ONLINE] Available at: <http://www.ers.usda.gov/data-products/organic-production.aspx#25762>.
- 259 European Commission Directorate General for Agriculture (2013) Facts and figures on organic farming in the European Union. [ONLINE] Available at: [http://ec.europa.eu/agriculture/rica/pdf/Organic\\_2016\\_web\\_new.pdf](http://ec.europa.eu/agriculture/rica/pdf/Organic_2016_web_new.pdf)
- 260 Chander, M. et al. (2011) Organic livestock production: An emerging opportunity with new challenges for producers in tropical countries. Scientific and Technical Review of the Office International des Epizooties, 30(3): 969–983.
- 261 Permaculture Research Association (n.d.). Livestock. [ONLINE] Available at <http://permaculturenews.org/category/animals/livestock/>
- 262 Broom, D. (2013) New research: Sustainable livestock production is possible with silvoculture. Permaculture Magazine. [ONLINE] Available at: <https://www.permaculture.co.uk/news/1311134023/new-research-sustainable-livestock-production-possible-silvoculture>
- 263 Broom, D. (2013) New research: Sustainable livestock production is possible with silvoculture. Permaculture Magazine. [ONLINE] Available at: <https://www.permaculture.co.uk/news/1311134023/new-research-sustainable-livestock-production-possible-silvoculture>
- 264 Vegetarian Society (n.d.) World history of vegetarianism. [ONLINE] Available at: <https://www.vegsoc.org/page.aspx?pid=830>
- 265 Biswas, S. (2018) The myth of the Indian vegetarian nation. BBC. [ONLINE] Available at: <http://www.bbc.co.uk/news/world-asia-india-43581122>
- 266 Shurtleff, W. and Aoyagi, A. (2014) History of meat alternatives (965 ce to 2014). SoyInfo Centre. [ONLINE]

- Available at: <http://www.soyinfocenter.com/pdf/179/MAL.pdf>
- 267 Vegetarian Society (n/a) World history of vegetarianism. [ONLINE] Available at: <https://www.vegsoc.org/page.aspx?pid=830>
- 268 Smith, E. (2015) The history of fake meat starts with the Seventh-Day Adventist Church. Atlas Obscura. [ONLINE] Available at: <https://www.atlasobscura.com/articles/the-history-of-fake-meat-starts-with-the-seventh-day-adventist-church>
- 269 Kellogg's (n.d.) Our best days are yours. [ONLINE] Available at: [https://www.kelloggs.com/en\\_US/who-we-are/our-history.html](https://www.kelloggs.com/en_US/who-we-are/our-history.html)
- 270 Reference for Business (n.d.) Worthington Foods. [ONLINE] Available at: <http://www.referenceforbusiness.com/history2/62/Worthington-Foods-Inc.html>
- 271 Business Green (2018) Vegan dividend: Quorn Foods reports record sales growth as global expansion pays off. [ONLINE] Available at: <https://www.businessgreen.com/bg/news/3026014/vegan-dividend-quorn-foods-reports-record-sales-growth-as-global-expansion-pays-off>
- 272 Wild, F. et al. (2014) The evolution of a plant-based alternative to meat: From niche markets to widely accepted meat alternatives. *Agro FOOD Industry Hi Tech*, 25(1).
- 273 Gates, B. (2013) Future of food. Gates' Notes. [ONLINE] Available at: <https://www.gatesnotes.com/About-Bill-Gates/Future-of-Food>
- 274 FoodBev Media (2018) Beyond Meat products to go on sale in 50 new countries this year, 9 May 2018. [ONLINE] Available at: <https://www.foodbev.com/news/beyond-meats-products-go-sale-50-new-countries-year/>
- 275 Fellet, M. (2015) A fresh take on fake meat. *ACS Central Science*, 1: 347–349. [ONLINE] Available at: <https://pubs.acs.org/doi/pdf/10.1021/acscentsci.5b00307>
- 276 Peters, A. (2017) Get ready for a meatless meat explosion, as big food gets on board. *Fast Company*, 18 December 2017. [ONLINE] Available at: <https://www.fastcompany.com/40508181/get-ready-for-a-meatless-meat-explosion-as-big-food-gets-on-board>
- 277 Dumitriu, S. (2018) Don't have a cow, man: The prospects for lab grown meat. Adam Smith Institute. [ONLINE] Available at: <https://www.adamsmith.org/research/dont-have-a-cow-man-the-prospects-for-lab-grown-meat>
- 278 Wolfson, S. (2018) WeWork will no longer serve meat at events or expense meals with it. *The Guardian*, 13 July 2018. [ONLINE] Available at: <https://www.theguardian.com/environment/2018/jul/13/wework-meat-events-expense-ban>
- 279 The Vegetarian Resource Group (2016) How many adults in the US are vegetarian and vegan? [ONLINE] Available at: [https://www.vrg.org/nutshell/Polls/2016\\_adults\\_veg.htm](https://www.vrg.org/nutshell/Polls/2016_adults_veg.htm)
- 280 Chiorando, M. (2017) Veganism skyrockets by 600% in America to 6% of population. *Plant Based News*. [ONLINE] Available at: <https://www.plantbasednews.org/post/veganism-skyrockets-by-600-in-america-over-3-years-to-6-of-population>
- 281 The Vegan Society (2016) Find out how many vegans are in Great Britain. [ONLINE] Available at: <https://www.vegansociety.com/whats-new/news/find-out-how-many-vegans-are-great-britain>
- 282 Dibb, S. (2017) The future is flexitarian. *Food Ethics Council*, 20 June 2017. [ONLINE] Available at: <https://www.foodethicscouncil.org/blog/146/19/the-future-is-flexitarian/>
- 283 Gelsky, J. (2018) Plant protein options for meat alternatives. *Food Business News*. [ONLINE] Available at: <https://www.foodbusinessnews.net/articles/11501-plant-protein-options-for-meat-alternatives>
- 284 Eurocommerce (2018) Trends in sales of meat products: A retail perspective. *Meat Market Observatory*. [ONLINE] Available at: [https://ec.europa.eu/agriculture/sites/agriculture/files/market-observatory/meat/doc/annex\\_4-trends-in-sales-meat-products-euro-commerce.pdf](https://ec.europa.eu/agriculture/sites/agriculture/files/market-observatory/meat/doc/annex_4-trends-in-sales-meat-products-euro-commerce.pdf)
- 285 Robinson, M. (2017) Generation Z is creating a \$5 billion market for fake meat and seafood. *Business Insider*. [ONLINE] Available at: <http://uk.businessinsider.com/generation-z-is-eating-fake-meat-2017-10>
- 286 Boyle, D. (2016) Generation moderation: Younger shoppers cutting back on the amount of meat they eat – and look down on binge drinking. *The Daily Mail*, 5 June 2016. [ONLINE] Available at: <http://www.dailymail.co.uk/news/article-3626458/Generation-Moderation-Younger-shoppers-cutting-meat-eat-look-binge-drinking.html>
- 287 Sainer, E. (2016) Fit, macho, sexy: The reinvention of vegans. *The Guardian*, 18 May 2016. [ONLINE] Available at: <https://www.theguardian.com/lifeandstyle/2016/may/18/vegans-veganism-fit-macho-sexy-beyon-ce-ufc-fighters-wellness-bloggers>
- 288 Boucher, D. (2016) Movie review: There's a vast cowspiracy about climate change. *Union of Concern Scientists*, 10 June 2016. [ONLINE] Available at: <https://blog.ucsusa.org/doug-boucher/cowspiracy-movie-review>
- 289 Homewood, A. (2015) Beware Cowspiracy – and the spread of the vegan virus. *The New Internationalist*, 24 September 2015. [ONLINE] Available at: <https://newint.org/blog/2015/09/24/cowspiracy-documentary-vegan/>
- 290 *Glamour Magazine* (2018) Celebrity vegans who make eating more veg look seriously sexy. [ONLINE] Available at: <https://www.glamourmagazine.co.uk/gallery/celebrities-who-are-vegan>
- 291 Sherrard, J. (2017) Alternative proteins: Will they steal our growth? [Podcast] *Rabobank*. [ONLINE] Available at: <https://research.rabobank.com/far/en/sectors/regional-food-agri/Podcast-Alternative-Proteins-Will-They-Steal-Our-Growth.html>
- 292 Euromonitor Research (2017) Has meat met its match? The future of plant-based protein. [ONLINE] Available at: <https://blog.euromonitor.com/2017/09/has-meat-met-its-match-the-future-of-plant-based-protein.html>
- 293 Euromonitor Research (2017) Has meat met its match? The future of plant-based protein. [ONLINE] Available at: <https://blog.euromonitor.com/2017/09/has-meat-met-its-match-the-future-of-plant-based-protein.html>
- 294 Mintel (2014) Number of global vegetarian food and drink product launches doubles between 2009 and 2013. [ONLINE] Available at: <http://www.mintel.com/press-centre/food-and-drink/number-of-global-vegetarian-food-and-drink-product-launches-doubles-between-2009-and-2013>
- 295 Vogel, S. (2017) Veggie meals won't kill your feed business: The impact of alternative proteins on livestock feed. *Rabobank*. [ONLINE] Available at: <https://research.rabobank.com/far/en/sectors/animal-protein/the-impact-of-alternative-proteins-on-livestock-feed.html>
- 296 Organisation for Economic Co-operation and Development (2018) Meat consumption. [ONLINE] Available at: <https://data.oecd.org/agroutput/meat-consumption.htm>
- 297 Euromonitor Research (2017) Has meat met its match? The future of plant-based protein. [ONLINE] Available at: <https://blog.euromonitor.com/2017/09/has-meat-met-its-match-the-future-of-plant-based-protein.html>
- 298 Markets and Markets (n.d.) Meat substitutes market worth 6.43 billion USD by 2023. [ONLINE] Available at: <https://www.marketsandmarkets.com/PressReleases/meat-substitutes.asp>
- 299 Peters, A. (2017) Get ready for a meatless meat explosion, as big food gets on board. *Fast Company*, 18 December 2017. [ONLINE] Available at: <https://www.fastcompany.com/40508181/get-ready-for-a-meatless-meat-explosion-as-big-food-gets-on-board>
- 300 Whipp, L. (2016) Big business identifies appetite for

- plant-based milk. Financial Times [ONLINE] Available at: <https://www.ft.com/content/7df72c04-491a-11e6-8d68-72e9211e86ab>.
- 301 Markets and Markets (n.d.) Meat substitutes market worth 6.43 billion USD by 2023. [ONLINE] Available at: <https://www.marketsandmarkets.com/PressReleases/meat-substitutes.asp>
- 302 Research and Markets (2018) Global dairy alternatives market 2018–2024: Consumption, forecast, and analysis by source, regions and companies. Business Wire, 29 January 2018. [ONLINE] Available at: <https://www.businesswire.com/news/home/20180129005608/en/Global-Dairy-Alternatives-Market-2018-2024-Consumption-Forecast>
- 303 Food and Agriculture Organization of the United Nations (2016) Trends in worldwide production, consumption and trade of pulses. [ONLINE] Available at: <http://www.fao.org/pulses-2016/news/news-detail/en/c/381491/>
- 304 Food and Agriculture Organization of the United Nations (2016) Pulses: Nutritious seeds for a sustainable future. [ONLINE] Available at: <http://www.fao.org/pulses-2016/en/>
- 305 Clonan, A. et al. (2012) The dilemma of healthy eating and environmental sustainability: The case of fish. Public Health Nutrition, 15(2): 277–284. [ONLINE] Available at: <https://www.cambridge.org/core/journals/public-health-nutrition/article/dilemma-of-healthy-eating-and-environmental-sustainability-the-case-of-fish/663B324CF05A1E0DD9FE7C1EE8B51926>
- 306 Farmery, A. et al. (2017) Assessing the inclusion of seafood in the sustainable diet literature. Fish and Fisheries, 18(3): 607–618. [ONLINE] Available at: <https://onlinelibrary.wiley.com/doi/abs/10.1111/faf.12205>
- 307 Thurstan, R. et al. (2014) The past and future of fish consumption: Can supplies meet healthy eating recommendations? Marine Pollution Bulletin, 89(1–2): 5–11. [ONLINE] Available at: <https://www.sciencedirect.com/science/article/pii/S0025326X14006080>
- 308 Pauley, D. et al. (2016) Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining. Nature Communications, 7(10244). [ONLINE] Available at: <https://www.nature.com/articles/ncomms10244?dom=pscau&src=syn>
- 309 Food and Agriculture Organization of the United Nations (2016) The state of world fisheries and aquaculture: Contributing to food security and nutrition for all. [ONLINE] Available at: <http://www.fao.org/3/a-i5555e.pdf>
- 310 Tacon, A. (2015) Feed matters: Satisfying the feed demand of aquaculture. Journal Reviews in Fisheries Science & Aquaculture, 23(1). [ONLINE] Available at: <https://www.tandfonline.com/doi/abs/10.1080/23308249.2014.987209>
- 311 Dibb, S. (2014) European Commission fails to deliver on sustainable food commitment. Eating Better, 6 October 2014. [ONLINE] Available at: <https://www.eating-better.org/blog/52/European-Commission-fails-to-deliver-on-sustainable-food-commitment.html>
- 312 D'Silva, J. et al. (2015) A crucial year for the planet. Compassion in World Farming. [ONLINE] Available at: <https://www.ciwf.org.uk/news/2015/01/a-crucial-year-for-the-planet/>
- 313 Staes, B. (2014) Outgoing EU commission accused of 'burying' key sustainable food legislation. The Parliament Magazine, 7 October 2014. [ONLINE] Available at: <https://www.theparliamentmagazine.eu/articles/news/outgoing-eu-commission-accused-burying-key-sustainable-food-legislation>
- 314 Teffer, P. (2015) Europeans should eat less meat, but EU keeps silent. EU Observer, 28 January 2015. [ONLINE] Available at: <https://euobserver.com/environment/127407>
- 315 Michail, N. (2017) Clash of the seitans: Lobbies locked in plant-based stalemate but near EU definition of vegetarian. Food Navigator, 29 May 2017. [ONLINE] Available at: <https://www.foodnavigator.com/Article/2017/05/24/Clash-of-the-Seitans-Lobbies-locked-in-plant-based-stalemate-but-near-EU-definition-of-vegetarian>
- 316 European Vegetarian Union (2018) EVU comments on the European Court of Justice's ruling on the use of dairy names for plant-based products. [ONLINE] Available at: <http://www.euroveg.eu/news/#milk>
- 317 Court of Justice of European Union (2017) Purely plant-based products cannot, in principle, be marketed with designations such as 'milk', 'cream', 'butter', 'cheese' or 'yoghurt', which are reserved by EU law for animal products. [ONLINE] Available at: <https://curia.europa.eu/jcms/upload/docs/application/pdf/2017-06/cp170063en.pdf>
- 318 The Economist (2017) Plant-based 'meat' is so tasty that Europe's meat industry has to bite back, 2 December 2017. [ONLINE] Available at: <http://media.economist.com/news/business/21731869-dutch-vegetarian-butcher-latest-come-under-attack-its-labelling-plant-based-meat>
- 319 Michail, N. (2017) Clash of the seitans: Lobbies locked in plant-based stalemate but near EU definition of vegetarian. Food Navigator, 29 May 2017. [ONLINE] Available at: <https://www.foodnavigator.com/Article/2017/05/24/Clash-of-the-Seitans-Lobbies-locked-in-plant-based-stalemate-but-near-EU-definition-of-vegetarian>
- 320 Dalton, J. (2018) France bans use of meat-like terms in packaging for vegetarian food. The Independent, 21 April 2018. [ONLINE] Available at: <https://www.independent.co.uk/news/world/europe/france-ban-vegetarian-vegan-meat-terms-packaging-burgers-steak-bacon-a8315626.html>
- 321 Gates Calderon, K. (2017) Dairy vs. plant-based 'milks': A regulatory standoff. Law 360. [ONLINE]. Available at: <https://www.shb.com/-/media/files/professionals/heinzlindsey/dairy-vs-plantbased-milks-a-regulatory-standoff.pdf>
- 322 Watson, E. (2017) Good Food Institute, NMPF, to FDA: Give the industry some clarity on plant 'milk' labelling. Food Navigator USA, 31 July 2017. [ONLINE] Available at: <https://www.foodnavigator-usa.com/Article/2017/07/31/Good-Food-Institute-to-FDA-Give-us-clarity-on-plant-milk-labels>
- 323 Millwards, D. (2018) Lab-grown vegetarian 'meat' rattles cattle ranchers. The Sydney Morning Herald, 2 April 2018. [ONLINE] Available at: <https://www.smh.com.au/environment/sustainability/lab-grown-vegetarian-meat-rattles-cattle-ranchers-20180402-p4z7f1.html>
- 324 Farming UK (2016) Food Standards Agency backs down over controversial #MeatFreeWeek tweet, 4 August 2016. [ONLINE] Available at: [https://www.farminguk.com/News/Food-Standards-Agency-backs-down-over-controversial-Meat-FreeWeek-tweet\\_42738.html](https://www.farminguk.com/News/Food-Standards-Agency-backs-down-over-controversial-Meat-FreeWeek-tweet_42738.html)
- 325 National Farmers' Union (2016) Meat industry acts on FSA Twitter promotions. [ONLINE] Available at: <https://www.nfuonline.com/sectors/livestock/livestock-news/meat-industry-acts-on-fsa-twitter-promotions/>
- 326 Black, A. (2016) Meat industry takes FSA meat free tweet complaint to PM. Farmers Guardian, 10 August 2016. [ONLINE] Available at: <https://www.fginsight.com/news/news/meat-industry-takes-fsa-meat-free-tweet-complaint-to-pm-14211>
- 327 Rabschnuk, A. (2018) Tyson launches 100% plant-based brand. The Good Food Institute. [ONLINE] Available at: <https://www.gfi.org/tyson-launches-100-plant-based-brand>
- 328 Dean Foods Company (2017) Dean Foods and Good Karma Foods strike investment and distribution deal to accelerate brand growth. Cision PR Newswire, 5 May 2017. [ONLINE] Available at: <https://www.prnewswire.com/news-releases/dean-foods-and-good-karma-foods-strike-investment-and-distribution-deal-to-accelerate-brand-growth-300452352.html>

- 329 Hall, R. (2018) Another record year for food and drink acquisitions in 2017. FoodBev Media, 16 January 2018. [ONLINE] Available at: <https://www.foodbev.com/news/another-record-year-for-food-and-drink-acquisitions-in-2017/>
- 330 Rabin, E. (2006) Ethical product marketing: Brave branding. GreenBiz, 9 April 2006. [ONLINE] Available at: <https://www.greenbiz.com/news/2006/04/09/ethical-product-marketing-brave-branding>
- 331 Holder, M. (2018) How Alpro plans to milk the plant-based diets trend. Business Green, 9 May 2018. [ONLINE] Available at: <https://www.businessgreen.com/bg/interview/3031909/not-milk-how-greener-diets-are-boosting-both-business-and-expectation-at-alpro>
- 332 Peters, A. (2017) Get ready for a meatless meat explosion, as big food gets on board. Fast Company, 18 December 2017. [ONLINE] Available at: <https://www.fastcompany.com/40508181/get-ready-for-a-meatless-meat-explosion-as-big-food-gets-on-board>
- 333 Tyson Foods Inc (2017) Annual report pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934. [ONLINE] Available at: [http://s1.q4cdn.com/900108309/files/doc\\_financials/2017/Q4/Tyson-2017-10K.pdf](http://s1.q4cdn.com/900108309/files/doc_financials/2017/Q4/Tyson-2017-10K.pdf)
- 334 Ethical Consumer (2018) 10 vegan food brands whose owners sell meat or dairy, 17 January 2018. [ONLINE] Available at: <http://www.ethicalconsumer.org/latest-news/entryid/2229/10-vegan-food-brands-whose-owners-sell-meat-or-dairy.aspx>
- 335 Ethical Consumer (2006) Takeovers of ethical companies. [ONLINE] Available at: <http://www.ethicalconsumer.org/commentanalysis/factsvgreenwash/ethicalcompanytakeovers.aspx>
- 336 Mufson, S. (2018) The oil giant that was 'forced to shrink to greatness'. The Washington Post, 15 July 2018. [ONLINE] Available at: <http://thewashingtonpost.newspaper-direct.com/epaper/viewer.aspx>
- 337 Massoudi, A. et al. (2016) Danone agrees \$12.5bn deal for health-focused WhiteWave Foods. Financial Times, 7 July 2016. [ONLINE] Available at: <https://www.ft.com/content/9ab78f12-43db-11e6-9b66-0712b3873ae1>
- 338 Business Wire (2013) WhiteWave spin-off from Dean Foods completed, 23 May 2013. [ONLINE] Available at: <https://www.businesswire.com/news/home/20130523006456/en/WhiteWave-Spin-off-Dean-Foods-Completed>
- 339 WhiteWave (n.d.) What we make. [ONLINE] Available at: <https://www.whitewave.com/what-we-make>
- 340 Ethical Consumer (2018) 10 vegan food brands whose owners sell meat or dairy, 17 January 2018. [ONLINE] Available at: <http://www.ethicalconsumer.org/latest-news/entryid/2229/10-vegan-food-brands-whose-owners-sell-meat-or-dairy.aspx>
- 341 Danone (2016) DANONE x WHITEWAVE: Accelerating our profitable growth journey by 2020 & driving the alimentation revolution. [ONLINE] Available at: [http://danone-danonecom-prod.s3.amazonaws.com/PUBLICATIONS/WW/DANONE\\_Factsheet-GB-ok-1304.pdf](http://danone-danonecom-prod.s3.amazonaws.com/PUBLICATIONS/WW/DANONE_Factsheet-GB-ok-1304.pdf)
- 342 Danone (2016) DANONE x WHITEWAVE: Accelerating our profitable growth journey by 2020 & driving the alimentation revolution. [ONLINE] Available at: [http://danone-danonecom-prod.s3.amazonaws.com/PUBLICATIONS/WW/DANONE\\_Factsheet-GB-ok-1304.pdf](http://danone-danonecom-prod.s3.amazonaws.com/PUBLICATIONS/WW/DANONE_Factsheet-GB-ok-1304.pdf)
- 343 Danone (2016) DANONE x WHITEWAVE: Accelerating our profitable growth journey by 2020 & driving the alimentation revolution. [ONLINE] Available at: [http://danone-danonecom-prod.s3.amazonaws.com/PUBLICATIONS/WW/DANONE\\_Factsheet-GB-ok-1304.pdf](http://danone-danonecom-prod.s3.amazonaws.com/PUBLICATIONS/WW/DANONE_Factsheet-GB-ok-1304.pdf)
- 344 Alpro (n/a) Embrace plant-based eating. [ONLINE] Available at: <https://www.alpro.com/healthprofessional/uk/plant-based-eating/balance-animal-plant-based>
- 345 Silk (n.d.) Progress is perfection. [ONLINE] Available at: <https://silk.com/progressisperfection>
- 346 Harrison-Dunn, A. (2016) Twitter storm blows up Alpro's dairy problem. NutraIngredients, 12 October 2016. [ONLINE] Available at: <https://www.nutraingredients.com/Article/2016/10/12/Twitter-storm-blows-up-Alpro-s-dairy-problem#>
- 347 Harrison-Dunn, A. (2016) Twitter storm blows up Alpro's dairy problem. NutraIngredients, 12 October 2016. [ONLINE] Available at: <https://www.nutraingredients.com/Article/2016/10/12/Twitter-storm-blows-up-Alpro-s-dairy-problem#>
- 348 Danone (2016) Climate policy: Target zero net carbon through solutions co-created with Danone's ecosystem. [ONLINE] Available at: [https://www.danone.com/content/dam/danone-corp/about-us-impact/policies-and-commitments/en/2016/2016\\_05\\_18\\_ClimatePolicy.pdf](https://www.danone.com/content/dam/danone-corp/about-us-impact/policies-and-commitments/en/2016/2016_05_18_ClimatePolicy.pdf)
- 349 GRAIN & IATP (2018) Emissions impossible: How big meat and dairy are heating up the planet. [ONLINE] Available at: <https://www.grain.org/article/entries/5976-emissions-impossible-how-big-meat-and-dairy-are-heating-up-the-planet>
- 350 Cellular Agriculture Society (n.d.) Homepage. [ONLINE] Available at: <https://www.cleanmeat.info/>
- 351 Dumitriu, S. (2018) Don't have a cow, man: The prospects for lab grown meat. Adam Smith Institute. [ONLINE] Available at: <https://www.adamsmith.org/research/dont-have-a-cow-man-the-prospects-for-lab-grown-meat>
- 352 Scully, M. (2018) Review: 'Clean meat' could make livestock obsolete. The Wall Street Journal, 5 January 2018. [ONLINE] Available at: <https://www.wsj.com/articles/review-clean-meat-could-make-livestock-obsolete-1515188032>
- 353 Beyond Meat (n.d.) Home page. [ONLINE] Available at: <http://beyondmeat.com/>
- 354 Impossible Foods (n.d.) Home page. [ONLINE] Available at: <http://www.impossiblefoods.com/>
- 355 Hampton Creek (n.d.) Home page. [ONLINE] Available at: <https://www.hamptoncreek.com/>
- 356 Memphis Meats (n.d.) Home page. [ONLINE] Available at: <http://www.memphismeats.com/>
- 357 Perfect Day Foods (n.d.) Home page. [ONLINE] Available at: <http://www.perfectdayfoods.com>
- 358 Kunst, J. R. et al.(2016) Meat eaters by dissociation: How we present, prepare and talk about meat increases willingness to eat meat by reducing empathy and disgust. Appetite, 105: 758-774. [ONLINE] Available at: <https://www.sciencedirect.com/science/article/pii/S0195666316302768?via%3Dihub>
- 359 Fox, K. (2017) Here's why you should turn your business vegan in 2018. Forbes, 27 December 2017. [ONLINE] Available at: <https://www.forbes.com/sites/katrina-fox/2017/12/27/heres-why-you-should-turn-your-business-vegan-in-2018/3/#196cc9a55e09>
- 360 Hayes, T. (2017) Why we are investing in alternative proteins. Tyson Foods. [ONLINE] Available at: <https://www.tysonfoods.com/who-we-are/the-feed/why-we-are-investing-alternative-proteins>
- 361 PHW (n.d.) Press. [ONLINE] Available at: <http://www.phw-gruppe.de/press-informationen-latest.html>
- 362 FAIRR (n.d.) Plant-based profits: Investment risks and opportunities in sustainable food systems. [ONLINE] Available at: <http://www.fairr.org/resource/plant-based-profits-investment-risks-opportunities-sustainable-food-systems/>
- 363 FAIRR (n.d.) Plant-based profits: Investment risks and opportunities in sustainable food systems. [ONLINE] Available at: <http://www.fairr.org/resource/plant-based-profits-investment-risks-opportunities-sustainable-food-systems/>

- 364 GRAIN & IATP (2018) Emissions impossible: How big meat and dairy are heating up the planet. [ONLINE] Available at: <https://www.grain.org/article/entries/5976-emissions-impossible-how-big-meat-and-dairy-are-heating-up-the-planet>
- 365 Roberts, D. (2018) The world's bleak climate situation, in 3 charts. VOX, 1 May 2018. [ONLINE] Available at: <https://www.vox.com/energy-and-environment/2018/4/30/17300946/global-warming-degreases-replace-fossil-fuels>
- 366 Geels, F. W. (2017) Sociotechnical transitions for deep decarbonisation. *Science*, 357(6357): 1242-1244. [ONLINE] Available at: <http://science.sciencemag.org/content/357/6357/1242>
- 367 Geels, F. W. (2014) Regime resistance against low-carbon transitions: Introducing politics and power into the multi-level perspective. *Theory, Culture and Society*, 31(5): 21-40. [ONLINE] Available at: <http://journals.sagepub.com/doi/full/10.1177/0263276414531627>
- 368 Geels, F. W. (2014) Regime resistance against low-carbon transitions: Introducing politics and power into the multi-level perspective. *Theory, Culture and Society*, 31(5): 21-40. [ONLINE] Available at: <http://journals.sagepub.com/doi/full/10.1177/0263276414531627>
- 369 European Commission (n.d.) NER 300 programme. [ONLINE] Available at: [https://ec.europa.eu/clima/policies/lowcarbon/ner300\\_en](https://ec.europa.eu/clima/policies/lowcarbon/ner300_en)
- 370 Covenant of Mayors for Climate & Energy (n.d.) Figures speak for themselves! Discover the Covenant of Mayors... in figures. [ONLINE] Available at: <https://www.covenantofmayors.eu/en/>
- 371 Carrington, D. (2017) Meat tax 'inevitable' to beat climate and health crises, says report. *The Guardian*, 11 December 2017. [ONLINE] Available at: <https://www.theguardian.com/environment/2017/dec/11/meat-tax-inevitable-to-beat-climate-and-health-crises-says-report>
- 372 Sustain (2018) Cities launch campaign to inspire people to eat more veg. [ONLINE] Available at: [https://www.sustainweb.org/news/aug18\\_vegcities/](https://www.sustainweb.org/news/aug18_vegcities/)
- 373 Marsh, S. and Owen, A. (2016) A meat-free Turin? Is Italy's first 'vegetarian city' a recipe for disaster? *The Guardian*, 4 November 2016. [ONLINE] Available at: <https://www.theguardian.com/cities/2016/nov/04/italy-first-vegetarian-city-turin-residents-divided-meat-free>
- 374 Jones, J. (2016) Barcelona officially declares itself a 'veggie friendly' city. *The Local*, 23 March 2016. [ONLINE] Available at: <https://www.thelocal.es/20160323/barcelona-declares-itself-a-veggie-friendly-city>
- 375 Bradle, H. (2018) The drought crisis must serve as a wakeup call to Agriculture Ministers. *CAP Reform EU*, 27 August 2018. [ONLINE] Available at: <http://capreform.eu/the-drought-crisis-must-serve-as-a-wakeup-call-to-agriculture-ministers/>
- 376 European Council (2017) Provisional deal on effort sharing emissions: Another step towards Paris targets. [ONLINE] Available at: <http://www.consilium.europa.eu/en/press/press-releases/2017/12/21/provisional-deal-on-effort-sharing-emissions-another-big-step-towards-paris-targets/>
- 377 Greenpeace (2018) Investigation: How the CAP promotes pollution: Summary of findings. [ONLINE] Available at: <http://www.greenpeace.org/eu-unit/Global/eu-unit/reports-briefings/2018/20180424-investigation-how-CAP-promotes-pollution.pdf>
- 378 IEEP (2017) Towards sustainability: Future policies for European livestock. [ONLINE] Available at: <https://ieep.eu/publications/bla>
- 379 IPES Food (n.d.) About us. [ONLINE] Available at: <http://www.ipes-food.org/>
- 380 Head, J. (2017) How do UK dietary guidelines compare for sustainability? *Medact*, 14 February 2017. [ONLINE] Available at: <https://www.medact.org/2017/blogs/uk-dietary-guidelines-compare-sustainability/>
- 381 Luo, L. (2016) The new Chinese dietary guidelines: What do they really say on meat consumption and sustainability? *Food Climate Research Network*. [ONLINE] Available at: <https://www.fcrn.org.uk/fcrn-blogs/lucy-luo/new-chinese-dietary-guidelines-%E2%80%93-what-do-they-really-say-meat-consumption-and>
- 382 Roös, E. (2015) Environmental concerns now in Sweden's newly launched dietary guidelines. *Food Climate Research Network*. [ONLINE] Available at: <https://www.fcrn.org.uk/fcrn-blogs/environmental-concerns-now-sweden-s-newly-launched-dietary-guidelines>
- 383 Green, M. (2016) Hogan pledges €15 million to promote EU meat consumption. *IEG Policy*, 6 October 2016. [ONLINE] Available at: <https://iegpolicy.agribusinessintelligence.informa.com/PL035163/Hogan-pledges-15-million-to-promote-EU-meat-consumption>
- 384 Di Croce, P. and other NGOs (2016) Letter to Commissioner Hogan 10.11.16. *Slow Food*. [ONLINE] Available at: <https://www.slowfood.com/slowlife/wp-content/uploads/161110-Letter-Slow-Food-et-al..pdf>
- 385 Cattlemen's Beef Board (2017) 2017 annual report. [ONLINE] Available at: <http://www.2017beefboardannualreport.org/>
- 386 National Pork's Board (2017) Audited financial statements and compliance report: Years ended 31 December, 2016 and 2015. [ONLINE] Available at: <http://www.porkcdn.com/sites/porkorg/library/2017/07/2016-Annual-Report.pdf>
- 387 American Egg Board (n.d.) Homepage. [ONLINE] Available at: <https://www.aeb.org/about-aeb/about>
- 388 Kowitt, B. (2016) Where's the beef? You won't be able to find out if agricultural groups get their way. *Fortune*, 2 May 2016. [ONLINE] Available at: <http://fortune.com/2016/05/02/wheres-the-beef-you-wont-be-able-to-find-out-if-agricultural-groups-get-their-way/>
- 389 Cartwright, M. et al. (2018) The government knows a plant-based diet is best - it should make it official. *Fast Company*, 23 March 2018. [ONLINE] Available at: <https://www.fastcompany.com/40548555/the-government-knows-a-plant-based-diet-is-best-it-should-make-it-official>
- 390 Program USDA's Agriculture and Food Research Initiative (AFRI) Competitive grants programme invite for the first time in 2018 proposals for projects in the areas of plant-based products and lab grown meat. [ONLINE] Available at: <https://nifa.usda.gov/sites/default/files/rfa/FY-2018-AFRI-Foundational-RFA.pdf>
- 391 Friedrich, B. (2018) Japanese government invests in clean meat! *The Good Food Institute*. [ONLINE] Available at: <http://www.gfi.org/japanese-government-invests-in-clean-meat>
- 392 US Department of Agriculture (2018) FY budget. Available at: <https://www.usda.gov/sites/default/files/documents/USDA-Budget-Summary-2018.pdf>
- 393 Integriculture (2018) Integriculture Inc. closes seed round led by Real Tech Fund at JPY 300 million [ONLINE] Available at: <http://integriculture.jp/?p=465>
- 394 Friedrich, B. (2018) Japanese government invests in clean meat! *The Good Food Institute*. [ONLINE] Available at: <http://www.gfi.org/japanese-government-invests-in-clean-meat>
- 395 Jones, B. (2017) China signed a \$300 million lab-grown meat deal with Israel. *Futurism*, 18 September 2017. [ONLINE] Available at: <https://futurism.com/china-signed-a-300-million-lab-grown-meat-deal-with-israel/>
- 396 Lyon, T. and Delmas, M. (2018) When corporations take credit for green deeds their lobbying may tell another story. *The Conversation*, 17 July 2018. [ONLINE] Available at: <https://theconversation.com/when-corporations-take-credit-for-green-deeds-their-lobbying-may-tell-another-story>

- ther-story-98988
- 397 Lyon, T. and Delmas, M. (2018) When corporations take credit for green deeds their lobbying may tell another story. *The Conversation*, 17 July 2018. [ONLINE] Available at: <https://theconversation.com/when-corporations-take-credit-for-green-deeds-their-lobbying-may-tell-another-story-98988>
- 398 Lyon, T. and Delmas, M. (2018) When corporations take credit for green deeds their lobbying may tell another story. *The Conversation*, 17 July 2018. [ONLINE] Available at: <https://theconversation.com/when-corporations-take-credit-for-green-deeds-their-lobbying-may-tell-another-story-98988>
- 399 Macalister, T. and Cross, E. (2000) BP rebrands on a global scale. *The Guardian*, 25 July 2000. [ONLINE] Available at: <https://www.theguardian.com/business/2000/jul/25/bp>
- 400 Browne, J., Nuttall, R. and Stadlen, T. (2016) BP's failed attempt to go 'beyond petroleum'. *Triple Pundit*, 4 October 2016. [ONLINE] Available at: <https://www.triplepundit.com/2016/10/bps-failed-attempt-go-beyond-petroleum/>
- 401 Mufson, S. (2018) The oil giant that was 'forced to shrink to greatness'. *The Washington Post*, 15 July 2018. [ONLINE] Available at: <http://thewashingtonpost.newspaper-direct.com/epaper/viewer.aspx>
- 402 Macalister, T. (2009) BP shuts alternative energy HQ. *The Guardian*, 29 June 2009. [ONLINE] Available at: <https://www.theguardian.com/business/2009/jun/28/bp-alternative-energy>
- 403 David, J. (2013) 'Beyond petroleum' no more? BP goes back to basics. *CNBC*, 22 April 2013. [ONLINE] Available at: <https://www.cnb.com/id/100647034>
- 404 Macalister, T. (2011) BP axes solar power business. *The Guardian*, 21 December 2011. [ONLINE] Available at: <https://www.theguardian.com/environment/2011/dec/21/bp-axe-solar-power-business>
- 405 Mufson, S. (2018) The oil giant that was 'forced to shrink to greatness'. *The Washington Post*, 15 July 2018. [ONLINE] Available at: <http://thewashingtonpost.newspaper-direct.com/epaper/viewer.aspx>
- 406 Vaughan, A. (2018) BP aims to invest more in renewables and clean energy. *The Guardian*, 6 February 2018. [ONLINE] Available at: <https://www.theguardian.com/business/2018/feb/06/bp-aims-to-invest-more-in-renewables-and-clean-energy>
- 407 Vaughan, A. (2018) BP buys UK's biggest electric car charger network for £130m. *The Guardian*, 28 June 2018. [ONLINE] Available at: <https://www.theguardian.com/business/2018/jun/28/bp-buys-uks-biggest-electric-car-charger-network-for-130m>
- 408 Ellyatt, H. (2017) Our renewable energy projects don't make us much profit yet, BP's Bob Dudley says. *CNBC*, 18 October 2017. [ONLINE] Available at: <https://www.cnb.com/2017/10/18/bp-ceo-bob-dudley-renewable-energy-projects-dont-make-us-much-profit.html>
- 409 Nelsen, A. (2016) EU dropped climate policies after BP threat of oil industry 'exodus'. *The Guardian*, 20 April 2016. [ONLINE] Available at: <https://www.theguardian.com/environment/2016/apr/20/eu-dropped-climate-policies-after-bp-threat-oil-industry-exodus>
- 410 Gilding, P. (2018) Disruptive markets: What sustainability really means for business, 16 August 2018. [ONLINE] Available at: <https://paulgilding.com/2018/08/16/disruptivemarkets/>
- 411 Perry, M. (2017) Fortune 500 firms 1955 v. 2017: Only 60 remain, thanks to the creative destruction that fuels economic prosperity. *AEIdeas*, 20 October 2017. [ONLINE] Available at: <http://www.aei.org/publication/fortune-500-firms-1955-v-2017-only-12-remain-thanks-to-the-creative-destruction-that-fuels-economic-prosperity/>
- 412 European Environment Agency (2016) Sustainability transitions: Now for the long term. [ONLINE] Available at: <https://www.eea.europa.eu/publications/sustainability-transitions-now-for-the/download>
- 413 Wellesley, L., Happer, C. and Froggatt, A. (2015) Changing climate, changing diets: Pathways to lower meat consumption. Chatham House. [ONLINE] Available at: [https://www.chathamhouse.org/sites/default/files/publications/research/CHHJ3820%20Diet%20and%20climate%20change%2018.11.15\\_WEB\\_NEW.pdf](https://www.chathamhouse.org/sites/default/files/publications/research/CHHJ3820%20Diet%20and%20climate%20change%2018.11.15_WEB_NEW.pdf)
- 414 Wellesley, L., Happer, C. and Froggatt, A. (2015) Changing climate, changing diets: Pathways to lower meat consumption. Chatham House. [ONLINE] Available at: [https://www.chathamhouse.org/sites/default/files/publications/research/CHHJ3820%20Diet%20and%20climate%20change%2018.11.15\\_WEB\\_NEW.pdf](https://www.chathamhouse.org/sites/default/files/publications/research/CHHJ3820%20Diet%20and%20climate%20change%2018.11.15_WEB_NEW.pdf)
- 415 Wellesley, L., Happer, C. and Froggatt, A. (2015) Changing climate, changing diets: Pathways to lower meat consumption. Chatham House. [ONLINE] Available at: [https://www.chathamhouse.org/sites/default/files/publications/research/CHHJ3820%20Diet%20and%20climate%20change%2018.11.15\\_WEB\\_NEW.pdf](https://www.chathamhouse.org/sites/default/files/publications/research/CHHJ3820%20Diet%20and%20climate%20change%2018.11.15_WEB_NEW.pdf)
- 416 Cockburn, H. (2018) Fears over climate change hit highest level in a decade following heatwave, study says. *The Independent*, 4 September 2018. [ONLINE] Available at: <https://www.independent.co.uk/environment/climate-change-heatwave-global-warming-opinion-poll-leo-barasi-a8522901.html>
- 417 Shapiro, P. (2018) Clean meat: How growing meat without animals will revolutionise dinner and the world. *Gallery Books*: 173.
- 418 Smithers, R. (2016) England's plastic bag usage drops 85% since 5p charge introduced. *The Guardian*, 30 July 2016. [ONLINE] Available at: <https://www.theguardian.com/environment/2016/jul/30/england-plastic-bag-usage-drops-85-per-cent-since-5p-charged-introduced>
- 419 Neslen, A. (2015) Fossil fuel firms accused of renewable lobby takeover to push gas. *The Guardian*, 22 January 2015. [ONLINE] Available at: <https://www.theguardian.com/environment/2015/jan/22/fossil-fuel-firms-accused-renewable-lobby-takeover-push-gas>
- 420 European Commission (2000) Communication from the Commission to the Council and the European Parliament: Implementing the Community Strategy to Reduce CO2 Emissions from Cars: First annual report on the effectiveness of the strategy. [ONLINE] Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52000DC0615>
- 421 European Commission (1998) Commission and ACEA agree on CO2 emissions from cars, 29 July 1998. [ONLINE] Available at: [http://europa.eu/rapid/press-release\\_IP-98-734\\_en.htm?locale=en](http://europa.eu/rapid/press-release_IP-98-734_en.htm?locale=en)
- 422 Mulvey, S. (2007) EU car CO2 fight only beginning. *BBC*, 7 February 2007. [ONLINE] Available at: <http://news.bbc.co.uk/1/hi/world/europe/6337057.stm>
- 423 Transport & Environment (2018) CO2 emissions from cars: The facts. [ONLINE] Available at: [https://www.transportenvironment.org/sites/te/files/publications/2018\\_04\\_CO2\\_emissions\\_cars\\_The\\_facts\\_report\\_final\\_0\\_0.pdf](https://www.transportenvironment.org/sites/te/files/publications/2018_04_CO2_emissions_cars_The_facts_report_final_0_0.pdf)
- 424 BBC (2017) Volkswagen diesel emissions fixing bill hits \$30bn, 29 September 2017. [ONLINE] Available at: <http://www.bbc.com/news/business-41442834>
- 425 Lima, P. (2016) Volkswagen blames customers for not buying electric cars. *PushEvs*, 22 November 2016. [ONLINE] Available at: <https://pushevs.com/2016/11/22/volkswagen-blames-customers-not-buying-electric-cars/>
- 426 Campbell, M., Rauwald, C. and Reiter, C. (2018) How Volkswagen walked away from a near-fatal crash. *Bloomberg Business*, 29 March 2018. [ONLINE] Available at: <https://www.bloomberg.com/news/features/2018-03-29/how-volkswagen-walked-away-from-a-near-fatal-crash>
- 427 Hildermeier, J. (2017) Carmakers failing to hit their own goals for sales of electric cars. *Transport & Environment*.



[ONLINE] Available at: [https://www.transportenvironment.org/sites/te/files/publications/2017\\_09\\_Car-makers\\_goals\\_EV\\_report\\_I.pdf](https://www.transportenvironment.org/sites/te/files/publications/2017_09_Car-makers_goals_EV_report_I.pdf)

- 428 McCarthy, N. (2018) Electric car sales are surging in China. Forbes, 1 June 2018. [ONLINE] Available at: <https://www.forbes.com/sites/niallmccarthy/2018/06/01/electric-car-sales-are-surging-in-china-infographic/#5fec5a8dd1f7>
- 429 Murphy, M. (2015) Tesla still has to beat Apple, Google, and the entire auto industry to win the electric car market. QZ, 22 September 2015. [ONLINE] Available at: <https://qz.com/505992/tesla-still-has-to-beat-apple-google-and-the-entire-auto-industry-to-win-the-electric-car-market/>
- 430 Nelsen, A. (2018) Crop failure and bankruptcy threaten farmers as drought grips Europe. The Guardian, 20 July 2018. [ONLINE] Available at: [https://www.theguardian.com/environment/2018/jul/20/crop-failure-and-bankruptcy-threaten-farmers-as-drought-grips-europe?CMP=tw\\_t\\_a-environment\\_b-gdneco](https://www.theguardian.com/environment/2018/jul/20/crop-failure-and-bankruptcy-threaten-farmers-as-drought-grips-europe?CMP=tw_t_a-environment_b-gdneco)
- 431 Elliott, L. (2018) Capitalism can crack climate change. But only if it takes risks. The Guardian, 16 August 2018. [ONLINE] Available at: [https://www.theguardian.com/commentisfree/2018/aug/16/capitalism-climate-change-risks-profits-china?CMP=Share\\_iOSApp\\_Other](https://www.theguardian.com/commentisfree/2018/aug/16/capitalism-climate-change-risks-profits-china?CMP=Share_iOSApp_Other)
- 432 Buckwell, A. and Nadeu, E. (2018) What is the safe operating space for EU livestock? RISE Foundation. [ONLINE] Available at: [http://www.risefoundation.eu/images/files/2018/2018\\_RISE\\_LIVESTOCK\\_EXEC\\_SUMM.pdf](http://www.risefoundation.eu/images/files/2018/2018_RISE_LIVESTOCK_EXEC_SUMM.pdf)
- 433 FAIRR (2017) The livestock levy: Are regulators considering meat taxes? [ONLINE] Available at: <http://www.fairr.org/resource/livestock-levy-regulators-considering-meat-taxes/>
- 434 Various Authors (2017) Open letter on industrial animal farming. [ONLINE] Available at: <https://openletteranimalfarming.com/welcome/>

