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Abstract While the human consumption of farmed animal products (FAPs) is rising at an unprecedented rate, the number of undernourished people exceeds 1 billion. FAPs can provide nutritional benefits, but their human health impacts, particularly how their consumption affects the health of others, have hardly been recognised. In this article the question of whether or not the consumption of FAPs causes human hunger is explored. A survey of the direct and indirect human health impacts is provided to shed light on this issue. As the farm animal sector (FAS) facilitates the emergence and spread of a large number of human diseases and produces a wide range of indirect human health impacts associated with land use and degradation, water use and pollution, and fossil fuel use and atmospheric pollution, the consumption of some FAPs is associated with an increase in stressors that cause human hunger. The United Nations, however, adopt the view that everyone has a right to food. If the existence of this right is accepted, it must be asked whether or not this right is jeopardised unjustifiably by the consumption of FAPs. Rather than adopt a simplistic proposal for equal per-capita shares, it is argued that what is needed is a careful, case-by-case consideration of how the consumption of FAPs might fit into a theory of global justice that allocates rights and duties, including the duty to safeguard the right to food of every human being.

Keywords animal, diet, environment, ethics, food, health

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INTRODUCTION

In its tenth progress report since the 1996 World Food Summit, the United Nations' Food and Agriculture Organization – which has defined hunger or undernourishment as a state “when caloric intake is below the minimum dietary energy requirement” – estimated that more than 1 billion people are undernourished.¹ In crude contrast, more than 1 billion people suffer from overnutrition as obesity and obesity-related diseases are increasing rapidly worldwide, a fact that has prompted some to speak of an “obesity pandemic”.² The rising incidence of a wide range of non-communicable diseases and of obesity-related health problems has been linked with an ongoing nutrition transition towards diets that are relatively rich in animal products, associated primarily with their high levels of saturated fats and low levels of antioxidants.^{3,4,5} This transition is associated with an unprecedented rise in what has been called “domesticated zoomass”, which is estimated to have grown from 180 million tonnes (Mt) in 1900 to 620 Mt in 2000, with “bovine biomass” having the largest share of 450Mt (p. 618).⁶

At the same time, several studies have recognised the role that animal products can play in the human quest for adequate nourishment.^{7,8,9} Generally, animal products are relatively energy-dense, rich in protein that contains the full range of amino acids (unlike most plant foods), calcium, vitamin B-12, riboflavin, and absorbable minerals such as iron and zinc as well as other micronutrients. In addition, many people obtain adequate levels of iodine by virtue of consuming dairy products from farmers who use iodinised products. In light of these benefits, some have argued that it is important that FAPs are included in the diets of people who might

otherwise lack adequate nutrition.^{10,11} In this respect, Tara Garnett has claimed that “where access to a nutritionally varied selection of foods is limited, and where there are serious problems of mal- and under-nutrition, keeping a goat, a pig, or a few chickens can make a critical difference to the adequacy of the diet” (p. 497).¹² Much human population growth in the near future is expected to occur in Asia, where demand for animal products is growing at an unprecedented rate. To meet the challenge of feeding this growing population, it has been argued that, in many rain-fed areas with relatively poor biophysical conditions, “ownership of animals is vital for survival, financial (“banks on hooves”) and food security, production of dung to sustain crop production, and enhancement of the natural resource base” (p. 15).¹³ In addition, some farm animals can serve other important functions, for example by providing draught power as well as means of transportation, thus saving on human labour and fossil fuel consumption. In India, for example, over 55% of the total land that was cultivated in 2009 included some involvement from draught animals.¹⁴ Whereas many services are provided by the FAS, the argument has been made that the multiple benefits that are provided by some systems, for example those associated with some forms of pastoralism, have not been given adequate recognition by policy-makers.^{15,16}

While it is beyond dispute that animals can provide food, either directly or indirectly, for those who might lack suitable alternatives, some scholars have claimed that eating FAPs can cause hunger.^{17,18,19,20} The renowned bioethicist Peter Singer, for example, has claimed that “the biggest part of the food crisis” stems from the fact that a lot of food that could be eaten by humans is fed to farm animals (p. 122).²¹ This claim is contested – albeit cautiously – by the authors of an influential report with the title “Livestock’s Long Shadow”, published by the Livestock, Environment, and Development Initiative (LEAD), a group co-ordinated by the Food and Agriculture Organization of the United Nations (FAO) (‘the LEAD study’), who claim that

“it is probably true that livestock do not detract food from those who currently go hungry” (p. 270).²² The objective of this article is to explore whether or not the consumption of FAPs causes people to suffer from hunger. A broad definition of FAPs is used here, including products derived from animals reared in extensive as well as intensive production systems, and from land-based as well as aquatic farm animals (aquaculture). In order to examine this issue, it is necessary to provide a succinct overview of how the consumption of FAPs might affect human health negatively.

DIRECT NEGATIVE HUMAN HEALTH IMPACTS OF FAPs

The consumption of some FAPs has been associated with a range of non-communicable diseases, including cardio-vascular diseases, diabetes, and some cancers.⁴ Apart from these, a review of 1,407 species of human pathogens found that more than half were zoonotic, i.e. transmitted from nonhuman to human animals, and the same review found that zoonoses account for almost three-quarters of all human diseases that emerged between 1980 and 2005.²³ Examples are different strains of swine and avian influenza, which pose serious human health concerns. Michael Greger, for example, has commented that the “same ‘trench-warfare’ conditions” that existed in 1918 (when the Spanish flu killed large numbers of people) can be found in many farm buildings that accommodate chickens today (p. 277).²⁴

While those who may contract any of these diseases might not suffer from hunger, we should not only be concerned with how the consumption of FAPs might cause hunger today, but also with how it might cause hunger in the future. In this light, the probability that a zoonotic disease that would cause illness and/or kill a large number of people might strike some time in

the future cannot be ignored, a possibility that has been recognised by those with an interest in food security.²⁵ There is no doubt that the social and economic disruptions that such a pandemic might cause would cause hunger. Even if many people who contract diseases that are caused by the farm animal industry may not go hungry, the financial resources that are used to combat them cannot be used at the same time to reduce undernutrition. It has been claimed that a reduction in the consumption of animal products would result in significant savings in health care costs.^{3,18,26,27,28,29} If this claim is correct, these savings could be used to secure other public goods, for example to invest in initiatives to reduce hunger and food insecurity, but it would be wrong to assume that they would necessarily be used for such purposes.

In order to claim convincingly that we ought to curtail the consumption of FAPs to increase funds to combat food insecurity, it is not sufficient to mention the costs associated with these health risks. Rather, it is necessary that we consider all the costs and benefits associated with the totality of the current FAS and explore if there might be alternatives with fewer costs and greater benefits, including a greater probability of reducing human hunger. This is why it is necessary to consider not only the more direct ways in which the consumption of FAPs might affect human hunger, but also the more indirect ways. Apart from producing a range of direct human health costs that might cause hunger, the FAS also produces a range of more indirect health problems that can contribute to ill health, including hunger, by affecting land, water, energy, and atmospheric resources. In this respect, the charge has been made that “destroying precious natural resources to produce meat may be equivalent to killing a poor man’s hen to obtain the eggs to feed a rich man”, a claim that will be examined in what follows (p. 651).³⁰

INDIRECT NEGATIVE HUMAN HEALTH IMPACTS OF FAPs

In many situations, humans do not use resources optimally by consuming FAPs. The land, water, and energy that are used to grow animal feed could frequently be used more efficiently if it was used to grow foods for direct human consumption.³¹ While the land, water, and energy requirements of different diets vary from place to place, depending (amongst other factors) on climate, water cycles, and the quality of the land, water, and the technologies that are available, diets that include FAPs generally require more resources.⁶ To address the question of whether the FAS jeopardises human food security by how it uses these resources, an overview will be provided of the key issues that we should consider, focussing on land, water, and air, or more precisely: land use and degradation, water use and pollution, and fossil fuel use and atmospheric pollution.

Land use and degradation

Diets that include FAPs generally require more land than other diets. While these findings cannot be generalised across different countries because of ecosystemic and technological differences, several studies carried out in various countries have concluded that there are significant differences in the land requirements of diets depending on both the amount and the kinds of FAPs they include, with diets that include FAPs requiring more land compared to diets that exclude them.^{32,33,34} For example, an American study has claimed that “an overwhelmingly vegetarian diet produced by modern high-intensity cropping” requires five times less arable land compared to “the typical Western diet” which uses “up to 4000 m²/capita” (p. 619).⁶ Similarly, a Dutch study concluded that the land used by an average Dutch household exceeds the land

required to feed a household at subsistence level by a factor of eight, or 3490 m² compared with 444 m², with the former household eating a much larger quantity of FAPs.³⁵

The land that is used to farm animals includes both arable and grazing land. About one third of the earth's soil surface is unsuitable for arable production, while it either is or could be producing grazing or browsing resources.³⁶ Provided that farm animals eat plants that are not suitable for human consumption and do not rely (heavily) on feed, diets that include FAPs need not necessarily use more land that could be used more efficiently to feed the human population. Indeed, the argument has been made that the ability of some farm animals to turn products that humans cannot eat into human-edible products "may become increasingly important in terms of global food security" (p. 330).³⁷ However, the reality is that a lot of arable land is used to feed farm animals. Over one-third of the world's harvest of cereals is fed to farm animals every year.²² While in many poor countries most grain is consumed directly by people, in many affluent countries – such as the United Kingdom – about 60% of the grain that is grown is fed to farm animals.³⁸ In addition, if Vaclav Smil is correct when claiming that "feed is sourced on a least-cost basis from international markets" (p. 1621)³⁹, a large amount of animal feed is imported from relatively poor countries, where some of this feed is grown on land that might have (had) more value by not being cultivated (for example, some rainforests) or by growing food crops. This is a growing concern as the amount of arable land that is being used to feed farm animals is increasing. This is associated with the fact that human diets are becoming less reliant on ruminants and more on pigs and chickens ('monogastrics') who depend more on feed. In addition, a growing number of ruminants are being fed feed crops.¹²

The use of arable land to feed farm animals is very inefficient. In the context of farming in the United States of America at the dawn of this millennium, Vaclav Smil has calculated that

4.5 kg of feed is required to produce 1 kg of edible body parts – which are frequently labelled more abstractly as ‘meat’ – from chickens, 9.4 kg of feed for 1 kg of edible meat from pigs, and 25 kg of feed for 1 kg of edible meat from feedlot-fed cows.⁶ While chickens are, at present, the best converters of plant-to-animal protein of all the animals reared for their meat, 80 percent of all the plant protein that is fed to them is not converted to protein that is edible by humans.⁶ While cows who are raised for their meat can live on grass, chickens and pigs are almost entirely reliant on feed.

As cows who are kept primarily to produce milk convert plant foods more efficiently into edible products compared to cows who are kept to produce meat, and as cows can digest roughages that would not be available for human consumption otherwise, some have welcomed further growth of a grass-based dairy industry.^{6,7} Comparing this with the production of “corn and soybeans” in Michigan – much of which is grown for dairy production at the present time, Michael Hamm has written that this would have “the potential to markedly reduce erosion on certain landscapes as well as reduce pesticide load in the environment”, as well as to provide additional calcium to the many people who fail to meet recommended levels (p. 181).⁷ If this is correct, this would provide a clear example of how an increase in the consumption of some FAPs could reduce nutritional problems.

However, there are at least two problems with Hamm’s proposal. Firstly, any proposal that speaks positively about an increase in dairy consumption must consider not only the additional calcium that this might provide, but also its other effects on those who would consume such products. Higher consumption of dairy products is not only associated with greater intakes of calcium, but also with higher intakes of saturated fats and cholesterol and their associated health concerns.

Secondly, before it can be concluded that any expansion of the dairy industry might be positive, it must be asked whether the balance between the costs and benefits associated with alternative methods to boost calcium intake might be more positive. Some studies have shown that diets that rely exclusively on the consumption of plant foods can provide sufficient dietary calcium.^{8,40} As a wide range of plant foods can be grown on the relatively fertile soils in the relatively benign climate of Michigan, for example kale, broccoli, and bok choy, greater consumption of such plant foods might well be able to provide for the additional need whilst meeting Hamm's interest in reducing particular environmental concerns at the same time. Increased consumption of specific plants would not only provide added calcium, but also replace some nutrients provided by the consumption of meat, thereby reducing demand for FAPs overall and their dependency on feed. Even if some of the land in question might not be suitable for the production of alternative sources of calcium, it does not imply that it should therefore be used by the dairy industry. For example, if we weigh up the moral costs and benefits of using a particular patch of land to grow biofuels, which would reduce our dependency on fossil fuels, it might be decided that this option should override using that land for grazing. Hamm's case would be strengthened if the land on which he suggests to keep cows could not be used to serve more important moral goals.

While Hamm is correct to claim that some diets that include particular FAPs contribute less to land degradation than other diets that include FAPs that are produced in different systems, in general, diets that include FAPs contribute more to land degradation compared to diets that exclude them. The definition of land degradation which I rely on here is the one provided by the United Nations Environment Program: "a reduction of resources potential by one or a combination of processes acting on the land, such as: (i) soil erosion by wind and/or water; (ii)

deterioration of the physical, chemical and biological or economic properties of soil; and (iii) long-term loss of natural vegetation”.⁴¹ Accepting this definition, the authors of the LEAD study claim that the FAS uses 70% of all agricultural land, and that some of this land should be taken out of cultivation to prevent further degradation. They add that about 20% of the world’s pastures and rangelands are degraded through overgrazing, compaction, and erosion caused by farm animals.²²

What must be added to the aforementioned definition is what might be the most important issue in relation to the challenge to counter land degradation: the loss of phosphorus obtained from mined rock phosphate, a key ingredient in most mineral fertilisers. While the quality of reserves of rock phosphate is declining and mining costs are increasing, a recent study has estimated that the reserves that remain could be used up by the end of the century and that they could reach a peak (maximum rate) by 2033.⁴² While the authors of the study point out that the continent with the greatest food shortages at the present time, Africa, exports more phosphate rock than any other continent, they also point out that a vegetable-based “diet demands significantly less phosphate fertilizer compared to a meat-based diet” (p. 297).⁴² Whereas this conclusion is misleading as the study extrapolates from data about phosphorus flows gathered in specific areas and does not provide evidence to suggest that this would apply to all diets that include FAPs, the fact that relatively large quantities of phosphate are used in many diets that include FAPs is nevertheless a significant cause for concern. The production of fertilisers from phosphate rock results in the production of large quantities of phosphogypsum, a toxic by-product that contains radionuclides of uranium and thorium. Some of these, as well as cadmium, end up in the soil when crushed rock phosphate is applied directly to it, as well as when processed phosphate fertilisers are applied that contain smaller quantities of these elements.⁴²

While phosphorus can, unlike oil, be recovered and reused, vast quantities of phosphorus leak from agricultural land. Long-term food security is therefore jeopardised by soil pollution from phosphate rock, as well as by the fact that – in the words of Cordell and co-authors – “there are no known alternatives to phosphate rock on the market today that could replace it on any significant scale” (p. 299).⁴²

Apart from being undermined by the toxic components of mineral rock phosphates, soil fertility can also be compromised by other practices associated with the farming of animals. Apart from cadmium, some soils are polluted by other metals used in the farming of animals, for example the use of zinc and copper as feed additives, as well as by veterinary medicines. The fertility of some soils is also jeopardised by nutrient loading – the accumulation of nutrients in the soil – caused by the application of excess quantities of manure and fertilisers. The soil is acidified by this excess and by ammonia (NH_3) emissions, resulting in reduced plant growth. About two thirds of anthropogenic ammonia emissions have been estimated to be produced by the farming of animals.²² Ammonia acidifies the soil by combining with oxygen to form nitrogen dioxide (NO_2), which can then combine with water and oxygen to produce nitric acid (HNO_3) and deposit as acid rain. Nutrient loading is a growing problem, as more farm animals are reared further away from their feed sources. An increasing number of animals are also reared in high density facilities, which have been associated with relatively poor waste management practices.¹² Some soils are also salinised (by the accumulation of salts in soils where evaporation is significant) and waterlogged by a range of irrigation methods that are used by the FAS to produce animal feed, thus undermining soil productivity.⁴³

Last but not least, the FAS is a major contributor to land degradation through deforestation. In 2000, Goodland and Pimentel estimated that about sixty percent of deforestation

took place to make room for animal farming.⁴⁴ More recently, Nepstad and colleagues identified the expansion of the FAS as the principal cause of deforestation in the Brazilian Amazon.⁴⁵ Not only the expansion of ranching, but also the production of animal feed has become a major contributing factor to the destruction of forests in Brazil. The LEAD study claims that, in the Latin American Amazon, the FAS uses about 70% of land that was previously forested as pastures and most of the remaining land to produce animal feed.²² The latter mainly relates to the farming of soybeans, which doubled its area to 22 million hectares during the decade leading up to 2004.⁴⁶ Most of the soybeans that are grown worldwide are crushed, producing 18.6% soy oil and 78.7% soy meal (and some waste), and – while the oil is used in a wide range of products (including biofuels) – almost all the meal is currently used to feed farm animals.⁴⁷ The LEAD study reports that world production of soybeans tripled between 1984 and 2004, and that half of this increase occurred between 1999 and 2004.²² While soybeans stimulate rapid growth of farm animals because of their high protein content, by current yields they require more land relative to other crops that are grown to feed animals per unit of animal product.⁴⁸ The soybean industry also contributes to deforestation by other human enterprises, as it is – in the words of Tara Garnett – “an important ‘push’ factor” by competing with other enterprises for land (p. 494).¹² Many ranchers who possessed lands suitable for soybean production have been able to sell off their lands at great profits due to increases in land prices stimulated by the soybean industry, and have used their profits to buy other lands that are cheaper and less suited for soybean production. A lot of soy that is grown in Brazil is not used locally, but exported to distant places, including China and the European Union. The latter imported about a third of Brazil’s cultivated soy in 2006/2007.⁴⁷ The European ban on feeding certain animal products to farm animals subsequent to the BSE crisis resulted in a surge in imports of soybeans into the European Union.⁴⁹ It has

been estimated that about ten million hectares of soybeans that are grown in non-European countries are imported by the European Union annually, representing an area that corresponds to 10% of the arable land of the European Union.⁴⁶ Because of the European ban on GM soybeans, most of its import of soybeans comes from Brazil, the sole large soybean producing country where the cultivation of GM soybeans is prohibited. Brazil also became the world's leading exporter of beef and exported 38% of its production to the European Union in 2004, whilst accounting for about half of the European Union's soy imports.⁴⁵ These facts show that the FAS is a major driver of deforestation and the associated loss in biodiversity.

It is time to take stock. On average, the FAS uses much more land per unit of food than the amount of land that other agricultural sectors require to produce a unit of food. In many situations, the sector also contributes more to land degradation than other agricultural sectors either are, or would be contributing, to produce a given unit of food. If competition over land use to produce food and land degradation cause hunger, the FAS causes human hunger.

Water use and pollution

Whereas water usage by farm animals varies depending on the nature of the animals, their feed, and the technologies used, as well as on the ecosystems in which they live, are killed and prepared for human consumption, it has been estimated that the production of FAPs generally requires more water compared to the production of other foods with similar nutritional content.^{50,51,52,53} For example, the production of meat has been estimated to use 8-10 times more water than the production of cereals.⁵³ What accounts for this large share is primarily the use of feed, a unit of which has been estimated to require at least 1,000 times its mass in water.^{6,54}

Overall, the LEAD study estimates that the FAS accounts for more than 8% of global human water use.²² A different study estimates that the sector uses about two thirds of the water used in food production, a quarter of which is attributed to grazing animals.⁵⁵ As many aquifers and other water sources are being emptied much faster than the rate by which the hydrological cycle can refill them, a lot of water is used at unsustainable rates.²²

Farm animals not only use large amounts of water, but grazing animals and the use of heavy agricultural machinery also reduce the replenishment of freshwater sources by lowering water tables as soil compaction reduces infiltration rates.⁵⁶ Since the farming of animals is the main cause of deforestation, the sector also causes water loss through reducing infiltration and water storage in deforested areas by removing canopies and reducing the soil's humus content. Water is not only used for drinking, but also to help with manure management and the cleaning of animal housing.

Not only the contribution of the FAS to the availability of water is an important issue, but also its contribution to water pollution. One source of pollution is the soil which ends up in water through the erosion and sedimentation caused by farm animals, either directly, or indirectly through deforestation. Another problem is the creation of dead zones. The nitrogen compounds and the phosphorus excreted by animals, together with the application of excessive quantities of fertilisers to grow their feed, can overfertilise the algae in rivers and seas and make them grow rapidly, a process known as eutrophication. When these short-lived algae die, they decompose whilst consuming oxygen, causing oxygen depletion (hypoxia) and the suffocation of aquatic ecosystems.⁵⁷ Eutrophication can also cause human health problems, for example by contributing to the development of *Pfiesteria piscicida*, an aquatic organism that not only kills fish but also causes gastrointestinal problems and temporary memory loss in humans. As an

increasing number of animals are kept in confined systems that are far removed from nutrient-deficient fields that might benefit from the nutrients provided by animal wastes, eutrophication is increasing.⁶

A further problem is the formation of nitrates from manure and artificial fertilisers. These can leach into drinking water supplies and filter through into the groundwater. While some studies have linked the human ingestion of nitrates with cancers and methaemoglobinaemia, the health effects of nitrate ingestion are the subject of considerable debate.^{58,59} The production of animal feeds is frequently associated with monocultures. Whereas monocultures also provide food that is directly consumed by human beings, the FAS uses relatively more artificial fertilisers to produce a fixed quantity of human food by relying on feed crops. This takes us to another issue. Since the spread of pests and plant diseases is enhanced by monocultures, monocropping is often associated with the use of large amounts of pesticides, some of which are known to be harmful to human health. The use of pesticides also contributes to the development of pesticide resistance, a growing problem, and some pesticide residues in water and food are known to pose human health risks.⁶⁰

Water is also polluted by the use of antibiotics. Many of the antibiotics used by the FAS are not used because the animals are ill, but simply to prevent disease, or the spread of it, as well as to promote growth.⁶¹ The Union of Concerned Scientists has estimated that the amount of antibiotics that are used by the FAS in the USA merely to prevent disease amongst animals who are reared in crowded conditions is eight times greater than the use of antibiotics to treat human disease. The development of multi-drug resistant strains of pathogenic bacteria is promoted by these practices.⁶² For example, Vancomycin-resistant enterococci – which can cause a range of infections in humans – may have been created by the use of Vancomycin on chicken farms. This

is a significant health concern, as many people's bowels contain Vancomycin-resistant enterococci and the Vancomycin-resistant genes have spread to some populations of the more common and more troublesome multi-drug resistant strains of staphylococcus aureus.^{63,64}

Hormones are also used to promote growth. Recombinant bovine somatotropin ('BST') is one of the most commonly used synthetic hormones in the United States of America, where it is administered widely to dairy cows, while its use in the dairy industry is prohibited in the European Union. There is significant debate over the health risks of these hormones, particularly in relation to the question if they can disrupt the human endocrine system as such disruptions have been documented in several species of other animals.⁶⁵ The farm animal industry also uses increasing amounts of detergents and disinfectants, as well as antiparasitic agents. Last but not least, some pathogens, for example cryptosporidium, thrive in water polluted by farm animals.^{66,67}

While this is not intended to be a complete survey of all water issues raised by the consumption of FAPs, we must also consider the negative impacts of some forms of aquaculture. While some methods to farm fish are associated with relatively small ecological footprints, for example the use of low trophic level species, others have been associated with relatively large ecological footprints because of their use of pesticides, prophylactic antibiotics, eutrophying nutrients, and their use of other fish as feed.⁶⁸ Other ecosystem changes associated with some forms of aquaculture may also be rather negative, such as for example the effects of some systems on wild species, and the rapid destruction of mangrove swamps in Southeast Asia that has taken place recently to meet the increasing demand – mainly from Western consumers – for shrimps.⁶⁹

To sum up: many systems that are used to farm animals jeopardise access to safe freshwater for all people. While relatively few people may be denied access to safe drinking water today because of these, the FAS jeopardises long-term food security by using relatively large amounts of freshwater, an increasingly scarce resource, and by contributing significantly to water pollution. Whereas producing food derived from pasture-fed animals may save water in systems that rely mainly on the use of rainwater, dietary shifts towards vegan diets could save large amounts of water compared to diets that include FAPs in many situations, especially where this replaces the consumption of FAPs derived from animals who are fed cereal crops.

Fossil fuel use and atmospheric pollution

The high yields that we have enjoyed in recent decades owe a great deal to the large-scale use of artificial fertilisers and pesticides, which are produced mainly from dwindling oil resources.⁷⁰ The production of FAPs generally requires more fossil fuels than the production of other foods per unit of nutritional benefit. As for water, this is related primarily to the fact that a large amount of plants that are eaten by animals do not become human food, but are used to maintain the animal's metabolism and turned into excreta and body parts that humans either do not or cannot eat.

In addition, the FAS contributes significantly to a wide range of problems caused by atmospheric pollution. Recent studies have claimed that there is a substantial risk that climate change will become increasingly dangerous if the average global surface temperature increases by more than 2°C relative to the pre-industrial temperature. According to a study by the Intergovernmental Panel on Climate Change (IPCC), the atmospheric concentration of

greenhouse gases was about 375 ppm (parts per million) in CO₂e (CO₂-equivalents) in 2005, and there is a growing consensus that concentrations will have to stabilise at or below that level to avoid a more than 2°C warming relative to the pre-industrial age.⁷¹ The implications of this are that global anthropogenic emissions must be cut by 50-85% relative to the 2000 level by 2050.^{71,72,73} The IPCC claim with “high confidence” – which is defined in terms of an 8 out of 10 chance – that, if we continue with a business-as-usual emissions policy, “the health status of millions of people is projected to be affected through” a range of conditions caused by climate change, including “increases in malnutrition” (p. 48).⁷⁴ In south Asia, for example, the food security of millions of people is already at risk from flooding, which has been reported to happen “more frequently and more severely than before” (p. 127).⁷⁵ Indeed, whilst this article is being written, Pakistan is suffering its worst flood in living memory.

Meanwhile, the greenhouse gas emissions produced by the FAS are rising steadily. A 2007 report published by the IPCC estimated that agriculture contributed 10-12% of all anthropogenic greenhouse gas emissions in 2005.⁷⁶ The study did not include, however, the emissions that result from land use changes associated with the FAS, as well as the emissions produced by the housing of farm animals, food processing, and agricultural machinery. A higher estimate has been provided by a report published for Greenpeace by a team from the University of Aberdeen, which gauges agriculture’s contribution to be between 17-32% of all anthropogenic emissions – the wide range being attributed mainly to the difficulties of calculating the emissions produced by different land use changes.⁷⁷ The aforementioned LEAD study has calculated the relative share of emissions produced by the FAS, claiming that it produced 18% of all anthropogenic greenhouse gas emissions in CO₂e in 2002.²² A succinct sketch of the most prominent contributing factors is provided.

Firstly, the FAS produces carbon dioxide (CO₂). Animals respire, producing CO₂. Whereas much of this CO₂ would also be emitted by plants breaking down if the animals were not there, some of it might remain out of the atmosphere for longer by being locked either inside plants or soils in a world wherein fewer farm animals would exist. The sector also causes deforestation and land use changes which release carbon and reduce the ability of soils and vegetation to store carbon. In addition, fossil fuels are used to operate agricultural machinery, and most synthetic fertilisers and pesticides are derived from oil. This implies that, by their production and use, carbon dioxide is released into the atmosphere. About 25% of all synthetic fertilisers and pesticides are used to produce animal feeds.²² Animal feeds are often grown far from where animals are kept, requiring transportation. Animals are also often reared far from where they are killed, turned into products, and consumed, and energy is required to house animals, as well as to transport and store their products. While these parameters vary between different places, David and Marcia Pimentel have calculated that, in the USA, the energy input from fossil fuels is more than 10 times greater for a unit of animal protein compared to a unit of plant protein, but they add that the nutritional value of a unit of animal protein as human food is 1.4 times greater than that of a unit of plant protein.⁷⁸ In total, the LEAD study estimates that the FAS accounts for 9% of anthropogenic CO₂ emissions.²²

The sector also produces methane (CH₄), mainly from enteric fermentation by ruminants and from stored manures, especially where these are stored in liquid form. The full contribution of methane to climate change has been estimated to be more than half that of carbon dioxide.⁷⁹ The LEAD study estimates that the FAS accounts for about 37% of all anthropogenic methane emissions.²² While this gas does not remain in the atmosphere for as long as CO₂, it has a global warming potential that is 72 times greater than that of CO₂ over 20 years (and 23 times over 100

years).⁸⁰ Whereas a reduction in the number of farm animals is likely to be accompanied by a decrease in methane emissions, it is also likely that reductions in some farm animal populations would go hand in hand with an increase in free-range animals who would occupy the freed-up space, and some of these would produce methane as well.

Chemical and organic nitrogen fertilisation also produces emissions of nitrogen oxide (NO_x), nitrous oxide (N_2O), and ammonia (NH_3). The creation of nitrous oxide in particular is a problem, as its microbial production from nitrogen in the soil is promoted where the available nitrogen exceeds plant requirements. The LEAD study estimates that the farm animal industry is responsible for 65% of anthropogenic nitrous oxide emissions, a gas with a global warming potential that is 289 times that of CO_2 over 20 years (and 298 times over 100 years) and that also contributes to the hole in the ozone layer.^{22,80} The sector also accounts for almost two thirds of anthropogenic ammonia emissions (mainly from manure), which contribute not only to global climate change, but also to acid rain.²²

Whilst the estimates provided here are supplied by the LEAD study²², a more recent study claims that the data provided by this study are a gross underestimate and that the total emissions of the sector amounted to 51% of all anthropogenic greenhouse gas emissions in CO_2 -equivalents in 2009.⁸¹ The main reasons for this significant difference are attributed to the following: that the former study did not include respiration as a source of emissions; that it did not factor in the opportunity costs associated with the fact that a lot of land (26 % of grassland and 33% of arable land) that is used by the FAS could regenerate as forest and capture much more carbon through photosynthesis or be used to grow biofuels that produce fewer emissions compared to fossil fuels; that it undercounted the number of farm animals (for example by excluding farmed fish and by relying on old data) and overlooked some emissions produced by

the production, distribution, and disposal of animal products, their byproducts, and their packaging; that it ignored the emissions produced by the pharmaceutical and medical industries in their fight against diseases associated with the FAS; and that an inappropriate global warming potential of 23, rather than the more appropriate figure of 72 was used for methane. With regard to this last reason, the authors justify their figure by pointing out that a 20-year timeframe (with global warming potential of 72) must be used rather than a 100-year timeframe “because of both the large effect that methane reductions can have within 20 years and the serious climate disruption expected within 20 years if no significant reduction of greenhouse gases is achieved” (p. 13).⁸¹ The figure of 51% provided in the Goodland and Anhang study dwarfs the figures calculated by most other studies. A much lower estimate of 14% was provided in a study which calculated the emissions from meat and dairy products in 27 countries of the European Union⁸², a finding that is in line with the 13% figure provided for the whole European Union in a report commissioned by the European Union.⁸³

While I shall not engage in a debate over the accuracy of these data, what is beyond any reasonable doubt from these studies is that the FAS presents a significant food security concern because of its contributions to fossil fuel depletion and climate change. The FAS is a major contributor to the decline of our reserves of fossil fuels. Since fossil fuel reserves are finite and diminishing rapidly, future generations will either have to go without or will have to cope with a much smaller share. If no alternatives are found to compensate fully for this loss, many people may suffer from hunger. The FAS is also a major contributor to climate change, which is expected to result in hunger for millions of people unless drastic and urgent action is taken. The more the sector contributes to climate change, the more agriculture itself will be jeopardised by the agricultural problems – including increased droughts and floods – that have been associated

with climate change. As several studies have shown that these problems will manifest themselves more in countries that are relatively poor already, it is very likely that this will result in rising human hunger.^{76,84,85,86}

THE QUEST FOR A SOLUTION

The United Nations has promulgated that every human being should have the right to food.⁸⁷ If the premise is accepted that all human beings have a right to adequate nutrition in a rapidly growing human population – which is expected to rise to around 9 billion by 2050 – it must be asked whether those diets that are most likely to jeopardise food security for all human beings survive moral scrutiny. To address this question, I shall engage with a proposal by Anthony McMichael et al.² These scholars are primarily concerned with the negative effects associated with climate change and argue that, in order to reduce (the likelihood of) these effects, the global consumption of meat should drop from the current average of 100 grams (g) to an average of 90 g per person per day (with less than 50 g coming from red meat derived from ruminants). This would stabilise greenhouse gas emissions from the FAS by 2050 relative to its contribution in 2005. They argue that this conclusion stands subject to a range of conditions. These include the assumptions that the global human population will have increased by no more than 40% by 2050; that the consumption of other FAPs would be reduced by a similar extent; and that current emissions would be reduced by 20% per unit of meat. McMichael et al. also propose that Aubrey Meyer's "contraction and convergence" model, which has been developed with the aim to cut down greenhouse gas emissions in general, could be applied to this area.⁸⁸

This proposal raises a number of concerns. The first is the question of whether reducing emissions by 20% per unit of production might be achievable. A working group on agriculture for the IPCC concluded in a recent report that “despite significant technical potential for mitigation in agriculture, there is evidence that little progress has been made in the implementation of mitigation measures at the global scale” (p. 500).⁷⁶ Therefore, if trends in recent history are anything to go by, a negative answer must be given. While the past may not be an accurate basis from which to predict the future, the LEAD study has recognised that curtailing the environmental impact of the FAS will be no mean feat, arguing that “the environmental impact of livestock production will worsen dramatically ... in the absence of major corrective features” (p. 275).²² While some studies have indicated that a 20 to 25% reduction might be possible, its feasibility must be doubted.^{82,89} This is so for various reasons, including the facts that it will require the global implementation of all available technological options, and that it will require immediate action. With regard to the latter point, the IPCC has argued that future agriculture will already be affected in many negative ways by climate change, with more negative than positive effects overall, and that these negative impacts will worsen unless more ambitious climate change abatement strategies are adopted urgently.⁸⁵

Secondly, while the team allow for consumption rates to vary between people, they nevertheless propose that all countries should reach the same average per person consumption level of 90 g per day. The problem with this proposal is that it ignores the different circumstances in which people living in different locations find themselves. For example, some people may rely more on the consumption of FAPs because they lack adequate and sufficient alternatives. Therefore, the consumption of FAPs may be the option which produces the least greenhouse gas emissions compared to its alternatives where these would need to be imported

from distant places. If the alternative options produced more greenhouse gas emissions, it would seem to be contrary to the authors' aim to reduce greenhouse gas emissions to expect people who live in such countries to reduce their intake of FAPs.

The most fundamental problem with this proposal, however, is the following. While Meyer's contraction and convergence model was conceived as a method to reduce greenhouse gas emissions, McMichael et al. use this model to propose the less ambitious aim of stabilising emissions in the FAS. This raises the question why this sector should only reach a stabilisation of emissions, whereas the emissions from other sectors are widely believed to be in need of significant reductions to achieve climate change abatement goals. For example, by passing the Climate Change Act 2008, the UK government has adopted the view of those scientists who claim that a reduction of at least 80% is required by 2050.⁹⁰ Also, both the Climate Change Act 2008 and the Kyoto Protocol take the 1990 emissions as the baseline level, whereas McMichael et al. merely seek for emissions to stabilise relative to the 2005 level. This reduces the contribution of this sector to climate change abatement strategies even further, especially since the global consumption of FAPs increased significantly between 1990 and 2005. If we focus on meat and ignore other animal products (the consumption of which has increased significantly as well), the LEAD study has estimated that, while the consumption of meat levelled off in "developed countries", total meat consumption in "developing countries" almost doubled between 1990 and 2002 (p. 15).²²

McMichael et al.'s proposal, therefore, raises many questions. If a mere stabilisation of emissions from the FAS is sought, other sectors will need to make more significant reductions in emissions to reach overall climate change abatement objectives. McMichael et al. do not explain, however, which sectors should make up for this deficit, and if it would be fair to expect more

drastic cuts from them. Whereas it may not be easy to make significant cuts in, say, the transport and energy sectors, further reductions in the consumption of FAPs may not only provide an important climate change abatement strategy, but also help to tackle a range of human health concerns, including human hunger. That we should commit to a reduction in consumption, rather than merely a reduction in the environmental impacts of consumption, is clearly borne out by a study which examined a whole range of environmental impacts associated with the consumption of FAPs in 27 countries of the European Union. The study found that the consumption of meat and dairy in these countries accounts for 24% of all monetarised environmental impacts from the total consumption of all goods, and that these products would still account for 19% after the full implementation of all considered improvement options. If the same study is correct in pointing out that the sector provides no more than 6% of the economic value of all final consumption in these countries, it can be concluded that – at least in the European Union – the financial costs of the FAS are considerable.⁸² More importantly, since the monetarised environmental impacts calculated by this study are likely to affect human food security in adverse ways, serious doubt must be cast over whether it would be worth having the imagined ‘improved’ FAS in the European Union at all.

However, the question of whether the consumption of FAPs should be curtailed should not be treated in isolation, but in the light of a theory of global justice which allocates duties in relation to protecting the right to food as well as other rights and interests that should be safeguarded. To be more specific, the consumption of FAPs should be considered in the light of our duties to safeguard the right to adequate health protection that we should grant to all, as I have argued elsewhere.⁹¹ I am, therefore, at one with Tim Lang in the view that a deliberate effort must be made to highlight justice issues in relation to food, in much the same way that

justice issues have come to the fore in relation to climate change.³ While such a theory will not be developed here, it is questionable whether McMichael et al.'s proposal survives ethical scrutiny. If the existence of a right to food is accepted and if this right is jeopardised by the consumption of particular FAPs in particular situations, whether people ought to make dietary changes should depend on the question of whether this right is jeopardised unfairly, rather than on a theory of what might be achievable by 2050 as a “working global target” (p. 1253).² This article has shown that there are several reasons why the FAS raises a significant concern in relation to securing the right to food of every human being. Before concluding, I would like to highlight that, on the basis of the health risks surveyed in this study, there are at least four reasons why a greater reduction in the consumption of farmed animal products than that proposed by McMichael et al. is required to safeguard the human right to food for all.

A first reason relates to the fact that the decline in reserves of rock phosphate and fossil fuels, the loss of soil fertility, the land degradation, the water scarcity, and the atmospheric pollution caused by the FAS are likely to compromise agricultural yields in the future, which would affect those who are least able to cope with price increases the most, unless they receive help from others. If Joel Cohen and Michael Lipton are correct that, because of the fact that – in many situations – those who demand animal products have greater purchasing power, the market is biased already towards fulfilling their demands, it must be doubted if poor people will manage to fulfil their food requirements in the future if any of these pressures increase, especially since many poor people already lack the financial power to feed themselves adequately today.^{92,93}

A second reason relates to the fact that the human population is growing at an unprecedented rate. It is expected that demand for food will increase by 70 to 100% by 2050.^{94,95} Meanwhile, global demand for FAPs has been predicted to double by 2050 relative to the

production level in 2000.²² The argument has been made, however, that there is limited potential for further expansion of agricultural land and that food increases will therefore have to come mainly from the land that is in production already.⁹⁶ This will be no mean feat, not in the least because the challenges raised by the negative impacts associated with the FAS will need to be addressed and because many countries have already reduced the gap between their actual yields and the yields that they could obtain in ideal growing conditions⁹⁷

A third reason why competition for food might increase relates to the fact that more land is being converted to the production of biofuels. If a prediction made by the World Bank turns into reality, as much as 40% of our global grain production could be used as biofuels by 2030.⁹⁸ Whereas there is no need to assume that this will be the case, the challenges raised by the additional pressure on resources, and the associated risks in relation to food security that are already exerted by the biofuel industry should not be downplayed.

Finally, there is little doubt that the biodiversity losses associated with some of the negative impacts of the FAS will have negative impacts on humanity's ability to respond to future food crises, as these losses not only diminish our ability to develop new foods and medicines, but also compromise yields. Unless the argument could be made that these negative impacts are a necessary price that we should pay, many people would seem to be obliged to curtail their consumption of FAPs if they value the right to food of every human being.

All of these reasons apply not only to the consumption of FAPs, but also to demand that the consumption of many other goods that produce relatively large quantities of negative 'Global Health Impacts' ('GHIs') should be curtailed. Elsewhere, I have argued that the acceptance of a general duty to limit negative GHIs is paramount, which may impose a more specific duty to restrict one's consumption of FAPs.⁸⁷

CONCLUSION

The authors of the LEAD study are right that the “livestock sector enters into more and direct competition for scarce land, water and other natural resources” (p. xxi).²² In the absence of corrective measures, this causes hunger for some of those who are least able to compete for food resources. While the authors of the LEAD study do not own up to this, if their claim that the FAS is marked by a “severe under-pricing of virtually all natural processes” that are used by it is correct – of which some prominent issues have been described in the preceding sections (p. 228)²², the logical conclusion that must be drawn is that some human beings either are already or will be paying the price for this, compromising the ability of some to enjoy adequate nutrition. This conclusion is sound unless the argument could be made that only the nonhuman world would be affected negatively by such under-pricing.

At the same time, it must be emphasised that any decrease in the consumption of FAPs will not, *ipso facto*, guarantee a greater availability of food for all people who suffer from hunger. There are several reasons why this must be concluded. Firstly, people are, and may be undernourished for a wide range of reasons that would not be changed for the better by a reduction in the consumption of FAPs. Secondly, any decrease in the consumption of FAPs may stem from the possibility that farmers are stimulated by the expanding biofuel sector to grow fuel crops rather than feed. Reductions in consumption would therefore not necessarily lead to a reduction in food prices so that those with the least purchasing power would not benefit.⁹⁹ Thirdly, it has been estimated that about 90% of all the arable land that could be turned over from providing feed to providing food crops is located within affluent countries.⁶ Consequently,

within the present context of a predominantly capitalist global economy, hungry people who lack sufficient cash to buy the food that might be grown on this land may not be able to benefit from such a diversion. Finally, the claim has been made that “50% of the estimated four billion rural poor are dependent on” farm animals “to maintain their basic quality of life” (p.8).¹³ If this is correct, there may be many situations where a decrease in the consumption of FAPs might be associated with an increase – at least in the short-term – in hunger, a conclusion which holds true unless any losses in the instrumental value of farm animals for human food security would be compensated for. If the claim that “extensive livestock production systems in developing countries are often only of marginal productivity ... leading to resource inefficiencies and often high levels of environmental damage per unit of output” is correct (p. 245)¹⁰⁰, and thus would not stem from “bias against the peasantry” (p. 299)¹⁰¹, however, many poor people who depend on farm animals may increase food security in the short-term, yet undermine it in the long-term.

In some situations, the consumption of FAPs alleviates hunger, in other situations it increases it, and in some situations it both reduces it (e.g., in the short term) and increases it (e.g., in the long term). In many situations, the consumption of FAPs jeopardises human food security. Whether or not this is a moral issue depends on the question of whether or not the human interest in food security is jeopardised unjustifiably. The claim has been made that agricultural policies and practices are frequently maintained and developed without adequate consideration for human health, including the human right to adequate nutrition.¹⁰² To conclude this paper, I would like to call for greater debate on food justice (as one aspect of a broader debate on global justice) and on which food items should be produced and consumed to comply with its demands, so that policy-makers can base their decisions about which food production systems they should support on the basis of such a debate. In light of the analysis presented here, both individuals as well as policy-

makers may decide that the FAS and the consumption of FAPs should be curtailed in some situations. I have discussed the different policy options that are available elsewhere, arguing that, because the FAS causes a wide range of other concerns apart from this article's concern with human hunger, the best policy option is to adopt a qualified ban on the consumption of FAPs.¹⁰³

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