What is a sustainable healthy diet?

A discussion paper

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Contents page

Introduction: the problem

The food system today is destroying the environment upon which future food production depends. It contributes to some 20-30% of anthropogenic greenhouse gas (GHG) emissions, is the leading cause of deforestation, land use change and biodiversity loss; accounts for 70% of all human water use and is a major source of water pollution. Moving from land to sea, unsustainable fishing practices deplete stocks of species we consume and also cause wider disruption to the marine environment. At the same time, the impacts of climatic and environmental change are starting to make food production more difficult and unpredictable in many regions of the world.

Although the whole food chain – from farming through to transport, cooking and waste disposal - contribute to these problems, it is at the agricultural stage where the greatest impacts occur. Both crop and livestock production generate environmental costs and recent years have seen the focus of attention falling in particular on the latter. The rearing of livestock for meat, eggs and milk generates some 14.5% of total global GHG emissions and utilises 70% of agricultural land (including a third of arable land, needed also for crop production).[1] [2] Grazing livestock, and less directly, the production of feed crops are together the main agricultural drivers of deforestation, biodiversity loss and land degradation.

While the food system generates enough food energy for our population of over 7 billion it does not deliver adequate and affordable nutrition for all. About half the global population is inadequately or inappropriately nourished, once the combined burdens of hunger, micronutrient deficiencies and obesity are taken into account.[3] [4] [5] And although food production and distribution contributes economic value both at a national and international level, the distribution of that value is not even. Many of the world's 1.3 billion smallholders and landless agricultural workers live on or below the poverty line. (World Bank 2008; Renwick et al 2012).[6] [7]

Without action, all these problems are set to become acute. As our global population grows, urbanises and becomes wealthier, it is demanding more resource intensive, energy rich foods – notably animal products - potentially damaging the environment further and exacerbating problems of obesity and chronic diseases.

These problems are well recognised. Policy makers, NGOs and the business community all agree that - if we are to address our environmental problems, adapt to climate change and

[1] Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. & Tempio, G. 2013. Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome.

[2] FAO (2006) Livestock's Long Shadow. Rome: Food and Agriculture Organisation

[3] Swinburn, B.A., Sacks, G., Hall, K.D., McPherson, K., Finegood, D.T., Moodie, M.L., Gortmaker, S.L., 2011. The global obesity pandemic: shaped by global drivers and local environments. The Lancet 378 (9793), 804e814.

[4] FAO, 2011. The State of Food Insecurity in the World. Food and Agriculture Organisation, Rome.

[5] Tulchinsky TH. 2010. Micronutrient deficiency conditions: global health issues. Public Health Reviews; 32:243-255.

[6] World Bank, World Development Report 2008: Agriculture for Development, Washington DC, 2007, 135 – 136.

[7] Renwick A, Islam M and Thomson S (2012). Power in Agriculture. Resources, Economics and Politics. A Report Prepared for the Oxford Farming Conference, UK

create a more food secure, nutrition enhancing food future - then the current food system needs to change.

There is less agreement on what, exactly, should be done. From a policy and industry perspective most of the focus in recent years has been on improving the environmental efficiency of production so as to produce more food with less impact. This entails using inputs more effectively, managing resource use and addressing deforestation. Others challenge this perspective, arguing that while 'production-side' approaches may be necessary, they are not sufficient. To address environmental concerns sufficiently and tackle the twin problems of dietary insufficiency and excess, three additional approaches will also be needed.

First there is a need to address power imbalances in the food system: throwing more food at the problem may not solve problems of affordability and access. Essential actions will therefore include efforts to address price and subsidy distortions, support and empower smallholder farmers and landless workers, agree better working conditions and fairer terms of trade, and improve transport and storage and market infrastructure.

Second we need to reduce the amount of food that is lost or wasted along the whole supply chain – one estimate puts the figure at between 30-50% of all food produced – which not only undermines food security but represents a waste of land, water and other inputs and the generation of 'unnecessary' emissions (IMECHE 2013).[8]

Third, diets will also need to change. What, and how much we eat directly affects what, and how much is produced. We therefore need to consume more 'sustainable diets' – diets that have lower environmental impacts, and are healthier.

But what does such a diet look like? Can health, environmental sustainability, and all the other goals we have for our food system really be reconciled, or will there be trade offs? These are the questions considered in this chapter.

Part one examines the issues that need considering in discussing what constitutes a sustainable diet and looks at how stakeholders have engaged in these discussions. Part two considers these issues in relation to the major food groups that constitute our diets. Part three offers some conclusions and makes suggestions for further research.

1. Sustainable diets: what needs to be considered?

While everyone agrees that our diets must be sustainable a comprehensive yet meaningful definition does not yet exist, since two underpinning questions remain unresolved. First: what is meant by sustainability? And second, 'what is good nutrition?' An answer to the question that then follows - "is a sustainable and healthy diet possible?" – will depend upon how the first two are answered.

1.1. Definitions of 'sustainability'

Definitions of sustainability vary. For some stakeholders, the word encompasses social and economic dimensions, where environment, economy and society (incorporating health and ethics) together constitute the 'triple pillars of sustainability.' However, others use the word more narrowly to refer to environmental objectives. More narrowly still sustainability may be used as a synonym for just one environmental goal, such as GHG reductions.

[8] IMECHE (2013). *Global food: Waste not, want not*, Institute of Mechanical Engineers, London, UK

both narrow and broad definitions come with attendant problems. Narrow definitions over simplify the issues and the multiple goals we have for the food system. On the other hand, very broad definitions tend to lack meaningful specificity. Take for example the FAO's definition of sustainable diets as: '… diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources' (FAO 2010). [9] While it is surely hard to disagree with this definition, it is very unclear what such a diet might look like on the plate. It also suggests that these multiple 'goods' are synergistic, when inevitably there will be trade offs.

Figure 1 highlights just a few of the issues that may need considering in defining a 'sustainable diet.'

Figure 1: Issues to consider when defining a sustainable diet

The amorphousness of the word sits at the root of disagreements: stakeholders not only define and use 'sustainability' differently but, even when they agree about its components, may prioritise issues in different ways. In the case of sustainable diets, environmental NGOs typically place strong emphasis on environmental concerns, on ethical dimensions such as animal welfare and fair terms of trade, and on certain aspects of health - in particular obesity

[9] FAO (2010). Final document: International Scientific Symposium Biodiversity and Sustainable Diets: United against Hunger. 3-5 November 2010, Food and Agriculture Organisation, Rome

and communicable diseases. They argue that policies and economic signals should be reconfigured to support positive health and environmental outcomes. The food industry tends to place stronger emphasis on mainstream economic goals and consumer demands, arguing the need to balance these against environmental concerns. Even within an issue, such as the environment, stakeholders may for example prioritise GHG reductions over biodiversity, or vice versa.

1.2. Defining good nutrition

Most stakeholders engaged in the sustainable diets debate nevertheless concede that such a diet should also be nutritionally adequate.

However when it comes to deciding what 'adequate nutrition' actually means, there is scope for considerable disagreement. Does nutritional adequacy refer to population averages or should the threshold be set at the level of the most nutritionally vulnerable? Judgements may be based on reference nutrient intakes; but these inevitably reflect a compromise between the state of knowledge as well as views on what constitutes acceptable risk and how far individuals' adapt in response to changes in nutrient availability. There may also be different opinions on the acceptability of strategies such as food fortification. At a deeper level, there are differing views on whether our goal is 'optimum' nutrition for the individual or 'good enough' nutrition for society as a whole – the latter to be considered in the context of other influences on health, such as the consequences of not addressing climate change or improving equity.

Critically, judgements about adequacy are underpinned by beliefs about cultural acceptability. For example, while it may technically be possible to obtain a particular micronutrient from various foods with differing environmental impacts, some will be more culturally acceptable than others. For some people, hypothetical modelled diets, however nutritious and low in environmental impacts (see Box 1), are simply not feasible since they do not reflect the way people eat. For others, the challenge lies in making the hypothetical real: in altering the social, cultural and economic influences on food choice in order to persuade, incentivise or otherwise cause people to eat differently. Thus, while the science is still uncertain and there is much more still to understand, discussions about nutritional adequacy, can never just be about the 'science'. Stakeholders' values, politics and ideologies will be equally important in informing judgements.

All these differences are most vividly manifested in discussions about the role of animal products – meat, dairy and fish – in the diet (2.3 below). Many forms of livestock production can carry heavy environmental costs but the issues are complex; the same can be said of the complex nutritional issues associated with their consumption. Moreover, these foods occupy a central place in our food culture and our thinking about what constitutes a 'proper' meal.

Of course, analysis of what constitutes a 'sustainable diet' needs to consider not just the *kinds* of foods we eat, but *how* they are produced. The method of production will determine how much food can be produced for a given level of environmental cost. Equally, the production method potentially influences a food's nutritional and other health properties.

Recent years have seen the spotlight falling on organic production. Organic standards specify, among other things, that foods be produced without artificial fertilisers and pesticides, antibiotics use in animal husbandry is kept to a minimum and that animals are reared to certain welfare standards. Some argue that food produced in this way is not only environmentally sustainable but also healthier. Is this really the case?

From an environmental point of view the issues are not simple. In countries such as the UK, studies find that organic products do not always have lower GHG emissions per kg. And while wildlife on organic farms tends to be higher than on conventional farms, since yields are generally lower, more land is required to produce a given quantity of food (Hodgson et al 2010).[10] This can reduce availability of uncultivated land and its associated wildlife. Since fertiliser and pesticide use in the UK have been falling over time, the gap between organic and conventional farming here has narrowed. This said, in a country such as China, where excessive fertiliser and pesticide use are causing major environmental damage to the point that they actually undermine yields, a shift towards lower input production (although not necessarily strictly organic) will, on balance, lead to environmental benefits (SAIN 2012).[11]

As regards health, two systematic reviews find no evidence that organic foods confer better nutrition although they note a lack of evidence as much as evidence of no impacts.[12][13] This said, organic products are less likely to contain pesticide residues or, in the case of meat, to be contaminated with bacteria potentially resistant to antibiotics. In general, pesticide residues are less of an issue in the UK where their use is well regulated, but the issue is certainly a concern in other parts of the world.

As to other aspects of production, some evidence suggests that grass fed animals are leaner, with their fat containing higher concentrations of beneficial omega 3 fatty acids than their grainfed counterparts.[14] [15] Studies also document increases in the fat content of poultry meat over the last thirty years, and a decline in the omega 3:6 balance.[16]

Other production issues to consider in relation to health are of course income and livelihoods for farmers and producers, as well as accessibility and affordability for consumers. A system of production and consumption that does not pay producers adequately or is not affordable will exacerbate the income inequalities that are key determinants of health status. The food sector's other influences on health include environmental health risks (e.g. water pollution, pesticides), infectious diseases (e.g. zoonotic & vector borne) & occupational injuries.

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[10] Hodgson JA; Kunin WE; Thomas CD; Benton TG; Gabriel D. 2010. Comparing organic farming and land sparing: optimizing yield and butterfly populations at a landscape scale *Ecol Lett* 13 1358-1367

[11] SAIN. (2012). Policies and technologies to overcome excessive and inefficient use of nitrogen fertiliser: delivering multiple benefits. SAIN policy brief no. 5. Norwich: Sustainable Agriculture Innovation Network

[12] Smith-Spangler C, Brandeau M L, Hunter G E, Bavinger J C, Pearson M, Eschbach P J, Sundaram V, Liu H, Schirmer P, Stave C, Olkin I, Bravata D M (2012). Are Organic Foods Safer or Healthier Than Conventional Alternatives? A Systematic Review. Annals of Internal Medicine;157(5):348-366.

[13] Dangour, A. D., Lock, K., Hayter, A., Aikenhead, A., Allen, E. & Uauy, R. (2010), Nutrition-related health effects of organic foods: a systematic review. *Am J Clinical Nutrition* 92, 203-210, published online doi:10.3945/ajcn.2010.29269

[14] Nuernberg K, Dannenberger D, Nuernberg G, Ender K, Boigt J, Scollan N D, Wood J D, Nute G R and Richardson R I (2005). Effect of a grass-based and a concentrate feeding system on meat quality characteristics and fatty acid composition of longissimus muscle in different cattle breeds, *Livestock Production Science* 94 137– 147

[15] Daley C A, Abbott A, Doyle P S, Nader G A and Larson S (2010). A review of fatty acid profiles and antioxidant content in grass-fed and grain-fed beef, *Nutrition Journal*, 9:10

[16] Wang Y, Lehane C, Ghebremeskel K, Crawford M.A. 2010, Modern organic and broiler chickens sold for human consumption provide more energy from fat than protein, Public Health Nutr. doi: 10.1017/S1368980009991157

2. Sustainable diets: how do the issues apply to specific foods?

How does this discussion relate to the individual foods that are consumed?

The Eatwell Plate – and the various visuals used by many other countries - provides guidance on how much of the different food groups should be consumed and, to a lesser extent, on the constituent foods that comprise those groups. Supporting advice also highlights the key nutrients associated with these groupings: calcium and magnesium for dairy foods and iron and zinc for meat– although of course most foods provide a range of different nutrients. These groups are discussed in turn and the section concludes with a few general observations.

2.1. Bread, rice, potatoes and pasta

The Eatwell Plate promotes consumption of staple carbohydrate foods including grains, potatoes and pasta. While Eatwell advises us to eat more of these foods than we do, increasingly the evidence suggests that not all carbohydrates are equal – the level of refinement is important too. Eatwell advises us to choose wholegrain varieties 'wherever possible.' In fact there is research to suggest that refined carbohydrates should be avoided since they provide inadequate levels of fibre and some studies have linked them to heart disease – a point that is relevant to the discussion on meat and its health impacts (see below). [17] [18] [19]

As to their environmental impacts, generally these foods (maize, wheat, potatoes and so forth) have a relatively low GHG footprint, with the exception of rice, whose production in paddies often requires irrigation, and generates high levels of methane. [20] However, there can be major issues as regards fertiliser, pesticide and irrigation use, and intensive monoculture production worldwide has had very damaging effects on a range of ecosystem services (Sutton et al 2011; Benton et al 2003, UK National Ecosystem Assessment 20). [21] [22] [23]

[17] Hu F (2010). Are refined carbohydrates worse than saturated fat? *Am J Clin Nutr*.; 91(6): 1541–1542.

[18] Jakobsen MU, Dethlefsen C, Joensen A M, Stegger J, Tjønneland A, Schmidt EB and Overvad K (2010). Intake of carbohydrates compared with intake of saturated fatty acids and risk of myocardial infarction: importance of the glycemic index. AJCN, 91 (6), 1764-8

[19] DiNicolantonio JJ. (2014) The cardiometabolic consequences of replacing saturated fats with carbohydrates or Ω-6polyunsaturated fats: Do the dietary guidelines have it wrong?. Open Heart;1

[20] Williams A, Hess, Chatterton J and Daccache A (2013). Are potatoes a low-impact food for GB consumers compared with rice and pasta? A report for the Potato Council, Cranfield University, UK.

[21] Sutton M A, Howard C M, Erisman J W, Billen G, Bleeker A, Grennfelt P, van Grinsven H and Grizzeti B (2013). *The European Nitrogen Assessment: Current problems and future solutions*. Cambridge University Press 2011

As to environmental differences between whole grain and refined versions, much depends on the particular food. Energy used to refine foods may reduce cooking times and associated energy requirements in the home – consider, say, the difference between brown and white rice. But cooking times for potatoes with and without skins will not differ while wholemeal bread has a lower carbon footprint than white.[24] While the balance differs slightly between foods, however, the differences are trivial. Compared with other food groups, the environmental impacts of this group are perhaps less significant. In general, greater consumption of whole grain carbohydrates, in line with Eatwell recommendations would likely benefit health; and while there are certainly substantial environmental problems associated with current systems of production, the overall impacts are, relatively speaking, lower than for other food groups.

The socio-economic dimensions of sustainability have received less attention and merit more attention. The issues here are diverse and range from concentration in seed supply - just three companies controlled nearly 50% of the world's seed market in 2007 (Renwick et al 2012)[25]- to the effects that health crazes in wealthy economies might have on the livelihoods of producers in poor countries. Take for example the growing popularity of quinoa – a nutrient rich whole grain, traditionally a staple for poor people in South America. The Food and Agriculture Organisation warns that rising global demand has increased quinoa prices to the extent that poor households within quinoa producing countries have been replacing quinoa with less expensive, but nutritionally inferior, food products, such as bread, pasta or rice. Over time, systems of production may adjust in line with global demand but the impact of those adjustments on smallholder production also remains to be seen (FAO 2013).[26]

2.2. Fruit and vegetables

The health benefits of consuming a plentiful and diverse range of fruit and vegetables are well recognised.

Many fruits and vegetables are low in environmental impact, but there are exceptions: impacts vary widely within this category and according to environmental issue.

As a rule of thumb, as regards GHG emissions, robust and field-grown produce such as brassicas, root vegetables, tubers and the harder fruits (eg. apples) generate relatively low impacts. Produce that is fragile (salads and berries), grown in

[22] Benton TG; Vickery JA; Wilson JD. 2003. Farmland biodiversity: is habitat heterogeneity the key? *Trends Ecol Evol* 18 182-188

[23] UK National Ecosystem Assessment (2011) The UK National Ecosystem Assessment: Synthesis of the Key Findings. UNEP-WCMC, Cambridge.

[24] Espinoza-Orias, Stichnothe H, Azapagic A (2011). The carbon footprint of bread. *The International Journal of Life Cycle Assessment* 16, 4, 351-365

[25] Renwick A, Islam M and Thomson S (2012). *Power in Agriculture. Resources, Economics and Politics*. A Report Prepared for the Oxford Farming Conference, UK

[26] FAO (2013). Food Outlook: Biannual Report On Global Food Markets, Food and Agriculture Organisation, Rome.

protected conditions (hothoused tomatoes or cucumbers), requires refrigeration (salads) very rapid and energy intensive modes of transport, such as air (green beans, mange touts, berries from the Southern hemisphere) are more GHG intensive. However, low GHG emissions may not always indicate an absence of other environmental impacts. While citrus fruits are not GHG intensive, they rely on irrigation which can exacerbate water stress in producing regions while for bananas, pesticides are an issue (Garnett 2006; Stoessel et al 2012; WRAP 2013).[27] [28] [29]

Some stakeholders promote local and seasonal produce. However, the benefits of local food have challenged by life cycle analysis which finds the production stage is often a greater determinant of overall impact than that of transport, the exception being air freighted foods. While foods that are both locally grown and in season are likely to have a lower environmental impact than the same foods produced overseas (British green beans compared with Kenyan imported beans in June),[30] in the colder months produce in-season overseas may have a lower footprint then their equivalents produced locally in heated greenhouses (Spanish versus British tomatoes). There are also issues such as waste and storage-related energy use to consider. The energy costs of storing locally produced foods beyond their natural growing season using refrigeration, freezing or canning, need to be compared with the energy costs of shipping in foods that are in season somewhere else, and of course with some other substitute food that is in season locally. In short, the issues are complex.

Are health and environmental goals in synergy? From a health perspective, quantity and diversity are key. The greater the quantity (within reason) and the more diverse one's consumption of fruit and vegetables the better. Achieving such diversity while also limiting consumption to more robust, lower impact produce is certainly possible – but it may require us to eat more brassicas and root vegetables and fewer perishable, hothoused or air freighted produce. Unfortunately, our food preferences are shifting in the opposite direction – towards higher impact produce (Defra 2013).[31] Notably fruit and vegetable waste levels are very high – it seems these higher environmental impact foods are not even benefitting us nutritionally, since we are not actually eating them.

There are also diverse socio economic issues to consider. While air freighting is highly GHG intensive, the African export horticulture sector provides jobs and livelihoods for an estimated 1-1.5 million people (Macgregor and Vorley 2006).[32] As such there is a trade-off between some environmental goals, and the immediate wellbeing of some of the world's most extreme poor. Low wages and poor working conditions are also an issue – our love affair with the banana creates retailer competition to keep prices low thereby driving down

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[27] Stoessel F, Juraske R, Pfister S and Hellweg S (2012). Life Cycle Inventory and Carbon and Water FoodPrint of Fruits and Vegetables: Application to a Swiss Retailer Environ Sci Technol. Mar 20, 2012; 46(6): 3253–3262.

[28] Garnett T. (2006) *Fruit, vegetables and UK greenhouse gas emissions: exploring the relationship*: A working paper produced as part of the work of the Food Climate Research Network, Centre for Environmental Strategy, University of Surrey

[29] http://www.wrap.org.uk/sites/files/wrap/Bananas%20v1.1.pdf

[30] Sim, S., Barry, M., Clift, R. and Cowell, S.J. (2007) The Relative Importance of Transport in Determining an Appropriate Sustainability Strategy for Food Sourcing. *Int J LCA* 12 (6) 422–431.

[31] Defra (20130. Family Food. Department for the Environment, Food and Rural Affairs, UK

[32] MacGregor J and Vorley B (2006). "*Fair miles*"*? The concept of* "*food miles*" *through a sustainable development lens*, International Institute for Environment and Development

plantation worker wages (Fairtrade Foundation 2009).[33] Within the UK, the horticulture sector has also been implicated in forced labour and exploitation of migrant workers, particularly during the summer picking season (Scott et al 2012).[34]

2.3. Meat, fish and alternatives

This category includes meat, fish, eggs, fish, pulses and legumes. The discussion here focuses on meat (with eggs included) and fish since they carry the highest environmental costs. Pulses are discussed in the context of their role as alternatives to these foods.

2.3.a. Meat

A growing body of academic research warns of the risks to society of not addressing meat consumption. Failure to do so will risk us further broaching our 'planetary boundaries'– boundaries related to atmospheric GHG concentrations, disruption of nitrogen and phosphorous cycles, freshwater depletion, biodiversity loss and so forth, whose transgression may trigger abrupt and possibly catastrophic environmental change (Pelletier and Tyedmers 2010; Rockström et al, 2009) .[35] [36] Many studies point out that improvements in technological efficiency will be insufficient to avert absolute increases in GHG emissions or deforestation (Popp et al 2010; Foley et al 2011; Ray et al 2013).[37] [38] [39] Even the Food and Agriculture Organisation concedes that while much can be done to improve the environmental efficiency of production it is "unlikely that the emission intensity gains, based on the deployment of current technology, will entirely offset the inflation of emissions related

[33] Fairtrade Foundation (2009). Unpeeling the banana trade. A Fairtrade Foundation Briefing Paper

[34] Scott S, Craig G and Geddes A (2012). Experiences of forced labour in the UK food industry, Joseph Rowntree Foundation, UK.

[35] Pelletier N and Tyedmers P (2010). Forecasting potential global environmental costs of livestock production 2000–2050, *PNAS* published ahead of print

[36] Rockström, J., W. Steffen, K. Noone, Å. Persson, F. S. Chapin, III, E. Lambin, T. M. Lenton, M. Scheffer, C. Folke, H. Schellnhuber, B. Nykvist, C. A. De Wit, T. Hughes, S. van der Leeuw, H. Rodhe, S. Sörlin, P. K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R. W. Corell, V. J. Fabry, J. Hansen, B. Walker, D. Liverman, K. Richardson, P. Crutzen, and J. Foley. (2009). Planetary boundaries:exploring the safe operating space for humanity. *Ecology and Society* 14(2): 32. [online] URL: http://www.ecologyandsociety.org/vol14/iss2/art32

[37] Foley J A, Rarmankutty N, Brauman K A, Cassidy E S, Gerber J S, Johnstone M, Mueller N D, O'Connell C, Ray D K, West P C, Balzer C, Bennett E M, Carpenter S R, Hill J, Monfreda C, Polasky S, Rockström J, Sheehan J, Seibert S, Tilman D and Zaks D P M (2011). Solutions for a cultivated planet, *Nature*. doi:10.1038/nature10452

[38] Ray DK, Mueller ND, West PC, Foley JA (2013) Yield Trends Are Insufficient to Double Global Crop Production by 2050. PLoS ONE 8(6): e66428. doi:10.1371/journal.pone.0066428

[39] Popp A, Lotze-Campen H & Bodirsky B (2010) Food consumption, diet shifts and associated non-CO2 greenhouse gases from agricultural production. Global Environ Change 20, 451–462

to the sector's growth." (Gerber et al 2013).[40] Indeed, increases in production efficiency arguably justify and incentivise further growth in output.

This all suggests that, unless we see a technological breakthrough, in order to achieve absolute reductions in food related environmental impacts, those who eat a lot of meat will need to eat less. An alternative view might of course be that we should let climate change take its course and adapt to its consequences, or else that other sectors of the economy, such as the transport sector, should be required to achieve even deeper cuts in emissions – but achieving these will be equally difficult and contested.

If – and this is still an *if* for some stakeholders – one accepts that meat intakes need to be reduced, at least three questions follow. First, what is the nutritional role of meat in the diet? Second what is an environmentally 'sustainable' amount of meat in the diet – and are some kinds of meat to be preferred over others? And third, what are the implications for human nutrition and health?

2.3.a.i. What is the role of meat in the diet?

The dietary role of meat depends on the context of consumption: this includes, among many other things, who you are, what else you eat, and what you are likely to eat in the absence of meat.

Taking people in low income countries first, almost no one suggests they should cut back on their consumption of animal source foods. For these people, diets are often monotonous, grain or tuber based and inadequate in both energy and key micronutrients. Overall increases in both the amount and diversity of foods consumed are critical – and this will include both animal and plant source foods.

The situation in a country such as the UK is different. With important exceptions, most people have access to, and can afford, a diverse range of foods of both plant and animal origin. On average expenditure on food constitutes a relatively low proportion of overall household spending. Diets are much more diverse than in low income countries even if they still fail to meet nutritional recommendations, and meat is an everyday staple, rather than a luxury food. In general the nutritional problems experienced, such as obesity and chronic disease, stem from overconsumption. The prevalence of undernutrition is low. While micronutrient deficiencies can be a problem for some groups (teenage girls, certain ethnic groups) when compared with the global situation, these must be seen as minor. The focus of the discussion here is largely on these rich world contexts.

2.3.a.ii. Nutrients in meat

Meat is an important source of protein and certain essential nutrients including iron, B vitamins, zinc and vitamin A. While these can all be obtained from plant sources or fortified foods (although sometimes in less biovailable forms), since many British people under-consume fruits, vegetables, whole grains and legumes, meat tends to be a disproportionately important dietary source of these nutrients. At the same time, in the forms in which we often eat it, meat oversupplies certain nutrients that we need to limit, such as saturated fat.

Thus meat provides a concentrated package of both 'positive' and 'negative' nutrients. Different types and formats of meat (red versus white, carcass versus processed) contain different balances of the positive and negatives.

[40] Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. & Tempio, G. 2013. Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome.

2.3.a.iii. Links between meat eating and health outcomes

Because meat comes in so many forms - from sausages to lean chicken breast – and because it contains both nutrients we value and those we do not, it is hard to link meat eating per se to particular health outcomes. The problem is compounded by the difficulty of adjusting for confounding factors, including foods that we eat alongside meat, and the different lifestyles of meat and non-meat eaters.

This said, a number of studies have sought to investigate the meat-health relationship. Studies focusing on high income countries such as the UK and US generally find an association between higher levels of meat eating and increased obesity and chronic diseases. This nature of this association, however, is highly contested.

It is possible to discern four pathways of association that form the focus of dispute concerning the meat-health relationship:

1. The first pathway links vegetarianism and veganism in affluent countries with lower average BMIs and all cause mortality. Among meat eaters, those who eat more meat have a higher BMI than those who eat less.[41] [42] [43] [44] [45] Critically, however, vegetarianism in these countries is a lifestyle choice and not a necessity. And on the whole, it is a choice made by people who are more educated, more health conscious, and less likely to smoke, drink too much, or be physically inactive than meat eaters. While studies generally adjust for these factors, stakeholders disagree as to how far this is fully possible.

For example, while environmental and animal welfare NGOs point to a link between meat eating and ill health,[46] others more aligned with food industry interests, emphasise the confounding factors.[47] Meat can be eaten as part of a healthy diet and research comparing health conscious meat eaters and vegetarians finds no difference in overall mortality or in

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[41] Sinha R, Cross A J, Graubard B I, Leitzmann M F and Schatzkin A (2009) Meat Intake and Mortality: A Prospective Study of Over Half a Million People *Arch Intern Med*.;169(6):562-571

[42] Vergnaud et al (2010). Meat consumption and prospective weight change in participants of the EPIC-PANACEA study *Am J Clin Nutr* 92: 2 398-407.

[43] Rosell M, Appleby P, Spencer E, Key T. Weight gain over 5 years in 21 966 meat-eating, fish-eating, vegetarian, and vegan men and women in EPIC-Oxford. *Int J Obes (Lond)*. 2006; 30 (9):1389-1396

[44] Romaguera, D., Norat, T., Vergnaud, A.C., Mouw, T., May, A.M., Agudo, A., Buckland, G., Slimani, N., Rinaldi, S., Couto, E., Clavel-Chapelon, F., Boutron-Ruault, M.C., Cottet, V., Rohrmann, S., Teucher, B., Bergmann, M., Boeing, H., Tjonneland, A., Halkjaer, J., Jakobsen, M.U., Dahm, C.C., Travier, N., Rodriguez, L., Sanchez, M.J., Amiano, P., Barricarte, A., Huerta, J.M., Luan, J., Wareham, N., Key, T.J., Spencer, E.A., Orfanos, P., Naska, A., Trichopoulou, A., Palli, D., Agnoli, C., Mattiello, A., Tumino, R., Vineis, P., Bueno-de-Mesquita, H.B., Buchner, F.L., Manjer, J., Wirfalt, E., Johansson, I., Hellstrom, V., Lund, E., Braaten, T., Engeset, D., Odysseos, A., Riboli, E. and Peeters, P.H. Mediterranean dietary patterns and prospective weight change in participants of the EPIC-PANACEA project. *Am J Clin Nutr*., 92(4), pp. 912-921

[45] Sinha R, Cross A J, Graubard B I, Leitzmann M F and Schatzkin A (2009) Meat Intake and Mortality: A Prospective Study of Over Half a Million People *Arch Intern Med*.;169(6):562-571

[46] CIWF (2008). Global warming, climate change and farm animal welfare, Compassion in World Farming, Godalming, UK.

[47] Wyness, L., Weichselbaum, E., O'Connor, A., Williams, E. B., Benelam, B., Riley, H. and Stanner, S. (2011), Red meat in the diet: an update. *Nutrition Bulletin*, 36: 34–77. doi: 10.1111/j.1467-3010.2010.01871.x

heart disease and cancers.[48] [49] As for the relationship with obesity, while NGOs highlight meat's central place in the unhealthy fast food meal package, the livestock sector emphasise the need to separate meat *per se* from the foods that are often eaten alongside it. Indeed, the livestock industry positions meat-based meals as an *opportunity* to eat vegetables (meat and two veg) [50] [51] - in contrast with approaches that point to meat as *substituting* for them. The industry points to the dangers of sarcopenia in elderly people, and its possible connection with insufficient protein intakes. [52] [53] [54] They also highlight the growing body of independent research suggesting that protein plays an important role in offering 'satiety' and thus in aiding weight *loss*.[55] [56] They warn of the 'substitution risk'- the possibility that policies to shift people away from eating meat might lead to people replacing them with less healthy refined carbohydrates. In short, while the evidence per se may be impartial, stakeholders tend to select and highlight the kinds of evidence that support their particular positions.

2. A second pathway linking meat and health is via saturated fat (WHO 2003; Hu et al 2001)[5758] - animal products are our main, although not the only source. Again this pathway is contested. Some studies suggest that while saturated fat may increase the risk of chronic disease, replacing fat with refined carbohydrates (a typical substitution in low fat foods) will not reduce and may even increase risks – although other studies still disagree.[59] [60] [61] [62] [63]

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[48] Key TJ, Appleby PN, Spencer EA et al. (2009) Mortality in British vegetarians: results from the European Prospective Investigation into Cancer and Nutrition (EPIC-Oxford). *Am J Clin Nutr* 89, Suppl., 1613S–1619S.

[49] Key TJ, Fraser GE, Thorogood M et al. (1999) Mortality in vegetarians and nonvegetarians: detailed findings from a collaborative analysis of 5 prospective studies. *Am J Clin Nutr* 70, Suppl., 516S–524S

[50] Wyness, L., Weichselbaum, E., O'Connor, A., Williams, E. B., Benelam, B., Riley, H. and Stanner, S. (2011), Red meat in the diet: an update. *Nutrition Bulletin*, 36: 34–77. doi: 10.1111/j.1467-3010.2010.01871.x

[51] *Beef up your fruit and veggies!* Cattlemen's Beef Board and National Cattlemen's Beef Association, 2007, 2007, Cattlemen's Beef Board and National Cattlemen's Beef Association http://beefnutrition.org/CMDocs/BeefNutrition/BeefUpYourFruitsandVeggies.pdf accessed 10 May 2012

[52] http://www.beefitswhatsfordinner.com/printads.aspx , Cattlemen's Beef Board and National Cattlemen's Beef Association

[53] Roussell M A, Hill A M, Gaugler T L, West S G, Vanden Heuvel J P, Alaupovic P, Gillies P J and Kris-Etherton P M Beef in an Optimal Lean Diet study: effects on lipids, lipoproteins, and apolipoproteins, *Am J Clin Nutr* doi: 10.3945/ajcn.111.016261

[54] Wyness, L., Weichselbaum, E., O'Connor, A., Williams, E. B., Benelam, B., Riley, H. and Stanner, S. (2011), Red meat in the diet: an update. *Nutrition Bulletin*, 36: 34–77. doi: 10.1111/j.1467-3010.2010.01871.x

[55] Red meat and weight management, Meat Advisory Panel, September 2011

[56] *Get Lean with Protein* produced by the Beef Checkoff for the National Cattlemen's Beef Association, undated, http://www.beefnutrition.org/CMDocs/BeefNutrition/GetLeanWithProtein.pdf accessed 10 May 2012

[57] WHO. (2003).Diet, nutrition and the prevention of chronic diseases. Report of a joint WHO/FAO expert consultation. Technical reportseries 916. Geneva: World Health Organization,

[58] Hu FB, Manson JE, Willett WC. 2001.Types of dietary fat and risk of coronary heart disease: a critical review. *J Am Coll Nutr*; 20: 5–19.

[59] Mente A, de Koning L, Shannon J S and Anand S S (2009). A Systematic Review of the Evidence Supporting a Causal Link Between Dietary Factors and Coronary Heart Disease *Arch Intern Med.* 2009;169(7):659-669

The livestock industry also points out that lean meat contains beneficial mono- and polyunsaturated fats, including omega-3 fatty acids.[64] [65] [66] Moreover, breeding efforts over the last sixty years have reduced the fat content of meat considerably: by 30% for pork, 15% for beef and 10% for lamb.[67] The industry emphasises the availability of leaner cuts and reminds us that we can simply trim off excessive fat. It argues too that stearic acid, a component of beef fat and in particular of dairy fat has no links with cardiovascular disease.[68]

3. The evidence on poultry meat (and fish) adds to the complexity. Studies linking red meat to disease also tend to find that these white meats are protective. For example the same two large scale studies finding a link between red and processed meat intakes and ill health, also found high white meat intakes to be protective. [69] [70] But environmental NGOs argue that their dependence on soy as a feed input implicates them in soy related deforestation, and in undermining food security (FOE 2008).[71] From an animal welfare perspective, these are the animals that are most likely to be intensively reared and thus represent most cause for concern. Thus welfare NGOs, for whom industrial low cost chicken represents a moral nadir, shift emphasis, highlighting the nutritional differences arising from different systems of

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[60] Astrup A, Dyerberg J, Elwood P, HermansenK, Hu F B, Jakobsen M U, Kok F J, Krauss R M, Lecerf J M, LeGrand P, Nestel P, Risérus U, Sanders T, Sinclair A, Stender S, Tholstrup T and Willett W C (2011). The role of reducing intakes of saturated fat in the prevention of cardiovascular disease: where does the evidence stand in 2010? Am J Clin Nutr;93:684–8

[61] Hu B H Editorial: Are refined carbohydrates worse than saturated fat? (2010). *Am J Clin Nutr*; 91:1541–2.

[62] Siri-Tarino P W, Sun Q, Hu F B and Krauss R M (2009). Meta-analysis of prospective cohort studies evaluating the association of saturated fat with cardiovascular disease, *Am J Clin Nutr* doi: 10.3945/ajcn.2009.27725

[63] Jebb SA, Lovegrove JA, Griffin BA, Frost GS, Moore CS, Chatfield MD, Bluck LJ, Williams CM, Sanders TA; RISCK Study Group. Effect of changing the amount and type of fat and carbohydrate on insulin sensitivity and cardiovascular risk: the RISCK (Reading, Imperial, Surrey, Cambridge, and Kings) trial. Am J Clin Nutr. 2010 Oct;92(4):748-58.

[64] Meat Advisory Panel *Red Meat and Health*, 2011 http://meatandhealth.redmeatinfo.com/sites/default/files/Red%20meat%20and%20saturated%20fat_0.pdf accessed 5 May 2012

[65] Meat Matters website http://meatmatters.redmeatinfo.com/health/redmeat-and-fat.aspx

[66] Wyness, L., Weichselbaum, E., O'Connor, A., Williams, E. B., Benelam, B., Riley, H. and Stanner, S. (2011), Red meat in the diet: an update. *Nutrition Bulletin*, 36: 34–77. doi: 10.1111/j.1467-3010.2010.01871.x

[67] http://meatandhealth.redmeatinfo.com/media/old/Red%20meat%20and%20saturated%20fat_0.pdf

[68] Stearic Acid: A unique saturated fat, National Cattlemen's Beef Association http://www.beefnutrition.org/CMDocs/BeefNutrition/StearicAcid.pdf accessed 10 May 2012

[69] Sinha R, Cross A J, Graubard B I, Leitzmann M F and Schatzkin A (2009) Meat Intake and Mortality: A Prospective Study of Over Half a Million People *Arch Intern Med*.;169(6):562-571

[70] Pan A, Sun Q, Bernstein A M, Schulze M B, Manson J, Stampfer M J, Willett W C and Hu F B (2012). Red Meat Consumption and Mortality Results From 2 Prospective Cohort Studies, *Arch Intern Med.* doi:10.1001/archinternmed.2011.2287

[71] FOE (2008). What's feeding our food? The environmental and social impacts of the livestock sector, Friends of the Earth, December

production, highlighting research indicating that: "[f]actory farmed meat chickens contain around one-third more fat than free-range organic chickens." They also underline the health risks associated with intensive production, including antibiotics use and food safety problems.[72] [73] [74]

4. As to the final, fourth pathway, research suggest that there is something specific about processed and potentially red meat that increases the risk of heart disease and colorectal cancer, although the mechanisms are not fully understood. A large scale prospective study found an association between both red and processed meat and premature mortality, cardiovascular disease and cancer even after adjustment for saturated fat, dietary cholesterol, and heme iron. [75] The World Cancer Research Fund concludes that these foods cause colorectal cancer; it advises that processed meat should be avoided altogether and red meat be limited to 500g/person/week (uncooked weight). [76] The UK Standing Advisory Committee on Nutrition is more cautious but suggests that capping intakes at 70g (cooked weight) a day. (SACN 2011). [77]

This, arguably is the only one of the four pathways that may be intrinsic to meat rather than associational. However, the nature of the dose-response relationship is not clear. Is all red and processed meat consumption risky, or only large quantities? For example, the red meat industry emphasises the point that average consumption levels (in the UK at least) are below the WRCF's recommended maximum[78] and interestingly, in its public discourse has started to position the SACN's recommended *maximum* as a 'guideline daily amount.'

In short, different attitudes, driven by different interests, lead to different judgements as to the role of meat in our diet. This by implication leads to different views on what the health impacts of lower meat consumption, driven by environmental objectives, might be. Are low or meat free diets compatible with health?

2.3.a.iv. Are low or meat free diets compatible with health?

The short answer to this question is 'yes.' While there will always be those who argue that humans simply cannot do without meat, generally speaking most nutritionists agree that with

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[72] CIWF (2009). Beyond Factory Farming: Sustainable Solutions for Animals, People and the Planet, Compassion in World Farming, Godalming, Surrey, UK.

[73] Wang, Y. Q. et al., 2005. Changes in protein and fat balance of some primary foods: implications for obesity. Presented at the 6th Congress of the International Society for the Study of Fatty Acids and Lipids. 27 June – July 2004, Brighton.

[74] Wang Y, Lehane C, Ghebremeskel K and Crawford MA (2010). Modern organic and broiler chickens sold for human consumption provide more energy from fat than protein, *Pub Health Nutri*, 13: 400

[75] Pan A, Sun Q, Bernstein A M, Schulze M B, Manson J, Stampfer M J, Willett W C and Hu F B (2012). Red Meat Consumption and Mortality Results From 2 Prospective Cohort Studies, *Arch Intern Med*. doi:10.1001/archinternmed.2011.2287

[76] WCRF/AICR. Food, nutrition, physical activity and the prevention of cancer: a global perspective. Washington DC: AICR, 2007

[77] SACN (2010) *Iron and health*, Scientific Advisory Committee on Nutrition, London

[78] *Red meat and cancer*, Meat Advisory Panel, September 2011 http://meatandhealth.redmeatinfo.com/sites/default/files/Red%20meat%20and%20cancer_0.pdf accessed 10 May 2012

care, a range of diets, differing in their meat content, can be compatible with health (ADA 2009). [79]

However this short and 'technical' answer does not do justice to the issues at stake and in particular to the values and assumptions people bring to the discussion about meat's role.

A growing number of academic studies (see box) conclude that diets with less meat in them could not only lead to savings in GHGs, land and water use, but also be consistent with or actively improve health. These findings are hardly surprising since the analysis is based on modelled 'ideal diets'. They do not model what might actually happen if -through a price change or other intervention- people ended up eating less meat. What would we eat instead, how would it change other aspects of our diet and what would the health implications be?

Of course much depends upon the nature of the intervention - changes in price alone might have different effects than if implemented in combination with other interventions, and different sub sectors of the population might also respond in different ways.

Box 1: Published research into the nutrition-environment relationship

There is a burgeoning academic literature that compares the environmental and nutritional impacts of meat and plant based diets. In general the approaches adopted tend to fall into the following categories:

One popular approach is to model the environmental and nutritional implications of current diets and then compare them with defined alternatives that differ in their animal product content. These alternatives may include 'healthy' diets that meet official guidelines, other recommended diets such as the 'Mediterranean,' or New Nordic, or 'Harvard Healthy Eating Plan', as well as idealised versions of vegetarian and vegan diets. Generally pulses and soy are specified as substitutes for the meat. Environmental impacts are assessed; and since diets are idealised ensuing health benefits are assumed. [80] [81] [82] [83]

A variant is to assess not only the environmental impacts but also the nutritional content of these modelled diets. Most consider only macronutrients (calories, fat, protein) and fruit and vegetable consumption,[84] [85] [86] although others consider micronutrients too. [87]

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[79] Position of the American Dietetic Association: Vegetarian Diets, *J Am Diet Assoc. 2009;109: 1266-1282.*

[80] Vanham D, Hoekstra A Y, Bidoglio G (2013). Potential water saving through changes in European diets Environment International 6145–56

[81] Stehfest E, Bouwman L, van Vuuren DP et al.(2009) Climate benefits of changing diet. Climatic Change, 95, 1–2.

[82] Pairotti M B, Cerutti A K, Martini F, Vesce E, Padovan D and Beltramo R (2014) Energy consumption and GHG emission of the Mediterranean diet: a systemic assessment using a hybrid LCA-IO method. *Journal of Cleaner Production* xxx 1e10

[83] Saxe H (2014). The New Nordic Diet is an effective tool in environmental protection: it reduces the associated socioeconomic cost of diet, Am J Clin Nutr doi:10.3945/ajcn.113.066746.

[84] Van Kernebeek HRJ, Oosting SJ, Feskens EJM, Gerber PJ and De Boer IJM (2014). The effect of nutritional quality on comparing environmental impacts of human diets, Journal of Cleaner Production xxx 1e-12

[85] Van Dooren C and Kramer G (2012). Food patterns and dietary recommendations in Spain, France and Sweden, www.livewellforlife.eu

However the Livewell study, commissioned by WWF takes an alternative and very detailed approach: it starts with official nutritional recommendations and adopts a linear optimisation approach to specify how these might be met at 25% less GHG cost, and in ways that are deemed to be culturally acceptable. In an extension of this approach, lower impact diets for four countries (Spain, France, UK and Sweden), each with different food cultures and consumption patterns were modelled. This time the diets not only needed to be not only culturally acceptable but also no more expensive than the current average. In all cases emission reductions could only be achieved by lowering the meat component and increasing the plant (including legume) component of the diets. The studies focus GHG emissions rather than other environmental concerns such as fish stocks or water use. [88] [89]

Another set of studies attempt to quantify not only the environmental impacts of meat reduction but also to link it to health, drawing upon meta-analyses linking meat consumption to health outcomes. Neither the environmental nor health implications resulting from consumption of alternatives to meat are considered.[90] [91] [92]

All these studies find that lower meat diets are less GHG - water or land intensive than the current average diets and that the lower the meat content of the diet, the lower the environmental impacts. They also find that these diets are compatible with nutritional recommendations and generally represent an improvement on current diets. Studies that model the impact of reduced meat intakes on actual health outcomes (eg. diabetes or heart disease) find reduced risks.

Vieux et al (2013) are distinctive in that they examine a range of real – as opposed to idealised - diets and compare the relationship their nutritional quality and environmental impact. [93] Classifying diets into four categories, they find that high nutritional quality diets generate greater GHG impacts than poorer diets. However it is important to note that differences in the nutritional quality of diets had little to do with differences in their meat component but rather in the quantities of fruit and vegetables and sweets and carbohydrates consumed. Better diets tend to be richer in the former which substitute for the sweets and

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[86] WWF UK (2011). Livewell: a balance of healthy and sustainable food choices, WWF UK, Godalming, UK

[87] Saxe H (2014). The New Nordic Diet is an effective tool in environmental protection: it reduces the associated socioeconomic cost of diet, Am J Clin Nutr doi:10.3945/ajcn.113.066746.

[88] WWF UK (2011). Livewell: a balance of healthy and sustainable food choices, WWF UK, Godalming, UK

[89] Van Dooren C and Kramer G (2012). Food patterns and dietary recommendations in Spain, France and Sweden, www.livewellforlife.eu

[90] Friel S, Dangour A, Garnett T, Lock K, Butler A, Butler CD, Chalabi Z, Roberts I, Waage J, McMichael A J, Haines A. (2009), *TheLancet*, 374: 2016–25.

[91] Aston L. M., JSmith. N. and Powles J. W. (2012). Impact of a reduced red and processed meat dietary pattern on disease risks and greenhouse gas emissions in the UK: a modelling study. BMJ Open; 2 (5): e001072 DOI: 10.1136/bmjopen-2012-001072

[92] Briggs A D M, Kehlbacher A, Tiffin R,Garnett T, Rayner M, Scarborough P, 2013. Assessing the impact on chronic disease of incorporating the societal cost of greenhouse gases into the price of food: an econometric and comparative risk assessment modelling study, *BMJ Open*.

[93] Vieux F, Soler L-G, Touazi D and Darmon N (2013). High nutritional quality is not associated with low greenhouse gas emissions in self-selected diets of French adults, Am J Clin Nutr; 97: 569–83

carbohydrates eaten by those with poor diets. Since sugary foods have a relatively lower GHG footprint (see 2.5), this explains the difference.

Finally almost all these studies define 'sustainability' in environmental terms alone. The Livewell series attempts to incorporate cultural preferences and consider the cost of alternative diets to consumers– generally finding these diets to be equivalent or cheaper than current diets –but the wider implications for the economy and society are not considered.

In the absence of empirical evidence, we are left to conjecture, and stakeholders will do so in different ways. Much depends upon what is posited as a consumption baseline, and what the alternative 'less meat' scenario is assumed to be. For environmental advocates the baseline is the typical diet of the average British citizen: meat is often consumed in the form of burgers, pies and sausages, it contributes unwanted saturated fat, and is eaten at the expense of whole grains, fruits and vegetables. These stakeholders then envisage an alternative consumption scenario in which these more desirable foods are eaten in the place of meat. The research approaches highlighted in Box 1 reinforce these views. For example, one NGO argues that a general shift to eating meat no more than three times a week could save 45,000 lives and £1.2bn in NHS costs each year."[94] In fact the commissioned research that underpins this claim models an alternative diet in which a number of changes, and not just to the meat content of the diet, have been made – reductions in meat are compensated for by increases in fruits and vegetables, legumes and grains, while sugars and fat intakes are also reduced. [95] Taken together it is somewhat disingenuous to conclude that the lower meat content alone is responsible for reduced mortality.

Those with more pro-meat tendencies however, take as their consumption baseline a balanced diet in which lean meat sits alongside vegetables, fruits and adequate carbohydrates. In their alternative consumption scenario, meat is replaced with refined carbohydrates and sugars, leading to micronutrient deficiencies and exacerbating in particular problems of iron deficiencies.[96]

In short, different stakeholders, depending on their underlying motivations, draw different conclusions based on the different emphases they place on the 'good' versus 'bad' nutrients they find in meat, on the relevance of confounding factors, and in what they assume the 'norm' to be, against which they posit an alternative consumption scenario. These different assumptions about baselines and replacement foods in turn leads to very different judgements as to the role of meat in the diet.

2.3.a. v. What is an environmentally sustainable level of meat consumption?

If it is not easy to specify a *nutritionally* optimal level of meat *consumption*, can one instead quantify an *environmentally* sustainable level of meat *production*, which would circumscribe how much can be consumed?
As with nutrition, there are multiple variables to consider:

[94] FOE (2010). Healthy Planet Eating: How lower meat diets can save lives and the planet, Friends of the Earth, UK.

[95] Scarborough P, Clarke D, Wickramasinghe K and Rayner M (2010). *Modelling the health impacts of the diets described in 'Eating the Planet' published by Friends of the Earth and Compassion in World Farming* , British Heart Foundation Health Promotion Research Group, Department of Public Health, University of Oxford http://www.dph.ox.ac.uk/bhfhprg/publicationsandreports/acad-publications/bhfhprgpublished/friendsoftheearthreport

[96] Wyness, L., Weichselbaum, E., O'Connor, A., Williams, E. B., Benelam, B., Riley, H. and Stanner, S. (2011), Red meat in the diet: an update. *Nutrition Bulletin*, 36: 34–77. doi: 10.1111/j.1467-3010.2010.01871.x

1. One is the pace of technological progress – scientific advances that increase the efficiency of livestock production will permit more meat consumption for a specified level of acceptable environmental cost. A second is which environmental concern is to be prioritised. For example, more poultry meat can be produced for a given volume of GHGs than lamb or beef; if GHG reductions are the priority, the former are preferable. Intensive production systems are more GHG efficient than less extensive ones whatever the livestock type – but there will be other non-GHG related costs. Dependence on irrigation water will be higher, and there will be problems arising from the build up of manure surpluses which cause disposal problems. Moreover, extensively reared sheep and cattle can be reared on land unsuited to other agricultural purposes, and (if well managed) help maintain biodiverse landscapes; can consume coarse agricultural byproducts; and are potentially less dependent on soy and other grain inputs, whose production requires good quality, and now scarce, arable land (UNEP 2009).[97] Arguably these systems of production are more resource efficient and more land sensitive, although GHG emissions are higher. Put another way, depending upon the quantity of consumption assumed, different approaches may be desirable. If one assumes that the increase in demand is inevitable, then feeding grains to poultry in intensive systems may be preferable since 'damage limitation' approach requires less land and emits fewer GHGs.

2. However, if demand can be moderated, then an alternative scenario may be preferred. Here cereal crops are grown only for human consumption and farm animals are confined to grazing on pasture or consuming byproducts. This 'livestock for resource efficiency' scenario could yield genuine ecosystem benefits but the amount of meat and dairy products available for consumption will be low.

3. A third variable concerns the way in which trade offs with other societal concerns are negotiated. For example, the most GHG 'efficient' production systems are those in which livestock are bred to be highly productive and kept in confinement, but they can also undermine important aspects of animal welfare, indicating a potential conflict between GHG efficiency and ethics.

4. Fourth, the more of an animal one is prepared to eat, the fewer animals are needed for a given quantity of meat. Such meat will include both cuts and organs that are low in fat – liver, kidneys, lean muscle – as well as fattier parts that are processed with added salt to improve palatability – sausages, mince, burgers and nuggets. This suggests a potential trade off between resource efficiency and nutritional quality.

While simple answers are not possible, what is clear is that an environmentally sustainable level of meat production will be substantially lower than the norm for high income consumers today.

Finally for this section, most of the focus on sustainable diets and meat has centred on the nutrition-environment relationship – but there are other important considerations too, such as non-nutritional health issues. Sixty percent of all known infectious diseases are zoonotic in origin, and 75% of new human pathogens reported in the past 25 years originated in animals (Tomley and Shirley 2009).[98]

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[97] UNEP (2009). *The environmental food crisis: The environment's role in averting future food crises*, Nairobi United Nations (2012) *FAO, partners, urge greater push to reduce food losses and waste*, 13 June 2012, Food and Agriculture Organisation, Rome http://un-foodsecurity.org/node/1345

[98] Tomley F M and Shirley M W (2009). Livestock infectious diseases and zoonoses. *Phil. Trans. R. Soc*. B 364, 2637-2642.

As regards the economy, estimates as to the role of livestock vary. The UK livestock sector contributes about 0.1% to the Gross Value Added of the UK economy (or 17% of the agriculture sector's 0.6%). [99] But this does not take into account, for example, its contribution to the landscape (tourism value) or the value added further along the supply chain via meat processing and retailing and the hospitality sector. The US meat and poultry industry claims that, through its direct and indirect ripple effects – such as through employee taxes – the sector contributes roughly $864.2 billion to the US economy, or 6% of US GDP.[100] Critics, on the other hand attribute substantial health and environmental costs to the US meat industry, and put these at about $414.8 billion (Simon 2013).[101] Moving from rich to poor countries, 70% of the world's ''extreme poor'' rely on animal rearing for their livelihoods (FAO, 2009) [102] and their critical nutritional importance has already been noted. Once again, the extent to which economic considerations are included in discussions of sustainability, how economic benefits and costs are attributed to livestock, and how the economic issues are framed, reflect the different starting points of the stakeholders.

2.3.b. Fish

A strong body of evidence finds that eating fish is good for health. The benefits are multiple - fish are high in protein and supply important micronutrients, but the omega 3 content, particularly of oily fish, is what receives the most attention. There is good evidence to suggest that long chain omega 3 fatty acids are protective against heart disease and potentially against other conditions (Mozaffarian 2006; SACN 2004).[103] [104] Since the body cannot manufacture long chain omega 3s, it has to obtain it from food. While the most abundant variant of Omega 3s, alphalinoleic acid (ALA) is readily found in plant such as flaxseed, it needs to be converted into longer chain eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) to be metabolised, and our bodies do not do this very efficiently. Oily fish provide EPAs and DHAs 'ready made' although they are also present to a lesser extent in grassfed ruminant meat. This said, while essential fatty acids are most bioavailable in fish, plenty of non-fish eaters in land-locked countries around the world live long and healthy lives without them.

And while fish may be good for health, many fish stocks are depleted. Overfishing harms not only the viability of target species but also the marine ecosystem more generally. Some limited attempts have been made in recent years to address the problem – for example the new EU Common Fisheries Policies is widely considered to be a useful step forward – and a number of fisheries are being managed in ways that meet sustainability standards. Some species are relatively unproblematic. Mussels are a case in point, being relatively rich in omega 3s, high in protein and able to obtain their food from the nutrients in seawater.

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[99] DEFRA (2013). Agriculture in the United Kingdom 2012, Department for the Environment, Food and Rural Affairs, UK.

[100] AMI (2011). The United States meat industry at a glance. American Meat Institute. http://www.meatami.com/ht/d/sp/i/47465/pid/47465

[101] 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, US

[102] FAO. 2009. The State of Food and Agriculture 2009:Livestock in the Balance, Rome. Food and Agriculture Organisation

[103] Mozaffarian D (2006). Fish Intake, Contaminants, and Human Health. Evaluating the Risks and the Benefits, JAMA, 296, 15, 1885-1899

[104] SACN (2004). Advice on fish consumption: benefits & risks, Standing Advisory Committee on Nutrition, UK.

However, from a global perspective there is simply not enough fish for everyone on the planet to consume in line with Eatwell Plate recommendations.

There are also reports that EU trawling vessels, illegally fishing in African waters, are outcompeting African fisherfolk, thereby depriving them of both food security and livelihoods (Brunner et al 2009). [105] Hence there is a clash between individual nutritional objectives and broader social and ecological priorities.

The health-environment-equity trade off is by now well recognised but the recommendation to consume fish still stands, in the UK as in other developed countries. One obvious question to ask is this: if a certain aspect of nutritional advice is not globally applicable, or actively undermines the nutritional wellbeing or others, or damages the sustainability of the ecosystem on which it depends, then to what extent is that advice legitimate? Should the wellbeing of more affluent individuals be privileged over the well being of the less affluent, of future generations, and of the ecosystem?

Solutions are being explored. For example trials are currently underway to genetically modify oilseeds to contain high levels of EPAs and DHAs (Ruiz-Lopez et al 2014, BBC 2014). [106] [107] Another option is to explore other plant based sources such as stearidonic acid, found in crops such as Bugglossoides which can be more readily converted to longer chain omega 3 fatty acids.[108] These may then be used instead of wild fishmeal as feeds for aquaculture production. However, it remains to be seen whether this approach is commercially feasible and of course questions of public acceptability remain.

2.4. Dairy

The issues with dairy are subtly different from meat, and potentially more complex. There is a long tradition of lacto-ovo vegetarianism in the UK; vegetarians are now not only well accepted by also well catered for by retailers and the catering sector. Among the public as a whole – and indeed across most cultures, milk tends to carry benign connotations of motherhood, love and care. This softer treatment of dairy products among the environmental community reflects the cultural embeddedness of milk and dairy foods.

However, cows are ruminants and as such milk products generate high environmental impacts. At the same time, dairy products are generally linked to positive health outcomes. Many studies suggest an inverse relationship between dairy

[105] Brunner E, Jones P, Friel S, Bartley M. Fish, human health and marine ecosystem health: policies in collision. 2009. International Journal of Epidemiology,; 38: 93-100.

[106] Ruiz-Lopez N, Haslam RP, Napier J A and Sayanova O (2014). Successful high-level accumulation of fish oil omega-3 long-chain polyunsaturated fatty acids in a transgenic oilseed crop, *The Plant Journal*, 77, 2, 198–208

[107] BBC (2014). http://www.bbc.co.uk/news/science-environment-25577155 accessed 7 March 2014

[108] Walker CG, Jebb SA, Calder PC. Nutrition. 2013 Stearidonic acid as a supplemental source of ω-3 polyunsaturated fatty acids to enhance status for improved human health. 29(2):363-9.

intakes and type 2 diabetes, elevated blood pressure, heart disease and colorectal cancer (Aune et al 2013; Alvarez-León 2006; Elwood et al 2008; Soedamah-Muthu 2011; Ralston et al 2012; Gibson et al 2009)[109] [110] [111] [112] [113] [114] [115] although also a direct association with prostate cancer (Marmot et al 2007).[116]

The benefits of dairy for bone health are much promoted by the dairy sector (Dairy Council, undated).[117] Milk is certainly a rich, low cost and culturally acceptable source of calcium; but this said, the influences on bone health are multiple and include but are not limited to calcium intakes. A USDA evidence review finds only "[M]oderate evidence" that "intake of milk and milk products is linked to improved bone health in children" and only "[L]imited evidence" in adults. (USDA 2010).[118]

The vegan community emphasises the importance of the other, non-calcium influences on bone health (Vitamin D etc.) as well as on the availability of plant based sources of calcium (PCRM, undated; Vegan Society, undated; Butler, undated). [119] [120] In fact bone fracture rates

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[109] Aune D, Norat T, Romundstad P and Vatten L J (2013.)Dairy products and the risk of type 2 diabetes: a systematic review and dose-response meta-analysis of cohort studies *Am J Clin Nutr 2013 ajcn.059030*

[110] Alvarez-León EE, Román-Viñas B, Serra-Majem L. Dairy products and health: A review of the epidemiological evidence. *Br J Nutr.* 2006; 96 Suppl 1: S94-S99.

[111] Elwood PC, Givens DI, Beswick AD, Fehily AM, Pickering JE, Gallacher J. The survival advantage of milk and dairy consumption: An overview of evidence from cohort studies of vascular diseases, diabetes and cancer. *J Am Coll Nutr.* 2008; 27 (6): 723S-734S

[112] Aune D, Lau R, Chan DSM, Vieira R, Greenwood DC, Kampman E and Norat T. (2012). Dairy products and colorectal cancer risk: a systematic review and meta-analysis of cohort studies *Ann Oncol* 23 (1): 37-45

[113] Soedamah-Muthu S S, Ding E L, Al-Lelaimy W K, Hu F B, Engbrerink M F, Willett W C and Geleijnse J M (2011). Milk and dairy consumption and incidence of cardiovascular diseases and all-cause mortality: dose-response meta-analysis of prospective cohort studies1–3, Am J Clin Nutr 2011;93:158–71

[114] Ralston R A, Lee J H, Truby H, Palermo C E and Walker K Z (2012). A systematic review and meta-analysis of elevated blood pressure and consumption of dairy foods, *Journal of Human Hypertension*, 26, 3–13; doi:10.1038/jhh.2011.3;

[115] Gibson R A, Makrides M, Smithers L G, Voevodin M and Sinclair A J (2009). The effect of dairy foods on CHD: a systematic review of prospective cohort studies, British Journal of Nutrition, 102(9):1267-75

[116] Marmot M, Atinmo T, Byers T et al. (2007) Food, Nutrition, Physical Activity and the Prevention of Cancer: a Global Perspective. WCRF/AICR Expert Report.Washington, DC: American Institute for Cancer Research; available at http://www.dietandcancerreport.org/downloads/Second_Expert_Report.pdf

[117] http://www.milk.co.uk/page.aspx?intPageID=49

[118] USDA (2010). *What is the relationship between the intake of milk and milk products and bone health?* Nutrition Evidence Library, United States Department of Agriculture, http://www.nel.gov/evidence.cfm?evidence_summary_id=250369

[119] Walsh S (2002). *Diet and bone health. A Vegan Society briefing paper* Vegan Society. UK. http://www.vegansociety.com/uploadedFiles/lifestyle/nutrition/DietandBoneHealthBooklet.pdf

[120] Butler J (undated). Boning up on Calcium! Why Plant Calcium is Best. Viva: The Vegetarian and Vegan Foundation, Bristol, UK http://www.vegetarian.org.uk/factsheets/calciumfactsheet.html

among vegans are on average 30% higher than in the general population. This however reflects lower average calcium intakes; vegans who consume the estimated average requirement of calcium, suffer a similar incidence of fractures as fish eaters and vegetarians (Appleby et al, 2007; Millward and Garnett 2010), [121] [122] It may also reflect lower on average BMIs. While this suggests that, with care, one can obtain adequate calcium from non dairy sources, this 'with care' observation links to the point made in the context of meat – do assessments of the role of dairy products assume impacts in an *ideal* world (of well informed, meal-planning, health conscious vegans) or in *practice* (the reality of greater bone fractures among people who may not have the necessary nutritional knowledge or interest)? In general dairy's critics tend to emphasis what is possible in principle, while its advocates emphasise what happens in practice. As noted above, when it comes to the links between meat and chronic diseases, the opposite positions are taken, with advocates of meat highlighting its potential to anchor a healthy diet while critics draw attention to the 'real life' link between meat eating, poor diets, and poor health.

As regards the economic dimensions of sustainability, US based work by Drewnowski (2011) finds that in milk is not only a 'nutrient dense' food but that it is by far the lowest-cost sources of riboflavin and vitamin B (12).[123] The situation is likely to be true in the UK too, although clearly the issues will be very different in low income countries.

From the farming perspective, however, supermarkets and dairy processors have historically used low milk prices to gain competitive advantage over rival companies, the result being that many smaller producers have been unable to farm profitably and have exited the sector. The situation may be stabilising, since recently prices have risen and with the removal of EU milk quotas in 2015 combined with strong demand for milk from Asian markets, the situation may improve for farmers. While this may deliver economic and livelihood benefits, growth in milk output will inevitably lead to a rise in dairy related GHG emissions.

Table 1: The main food groups: summary of environmental, nutritional and societal considerations

Food groups	Environmental considerations	Influences on nutrition	Health advice and implications	Other sustainability dimensions
Bread, rice, grains, potatoes and pasta	Lower GHG impact to produce; processing requires energy to be balanced against occasionally longer cooking times. Rice is GHG & water intensive. Other	Quantity consumed Level of processing (white versus wholegrain) Type (potatoes versus rice) Accompaniments co-consumed (eg. fats, spreads	Eatwell recommends consuming more of these portions, ideally in less processed form. Other studies warn against refined carbohydrates and specify wholegrains.	Implications of demand for quinoa on food security of South American poor?

[121] Appleby P, Roddam A, Allen N et al. (2007) Comparative fracture risk in vegetarians and nonvegetarians in EPIC Oxford. *Eur J Clin Nutr 61*, 1400–1406.

[122] Millward D J and Garnett T (2010). Plenary Lecture 3: Food and the planet: nutritional dilemmas of greenhouse gas emission reductions through reduced intakes of meat and dairy foods *Proceedings of the Nutrition Society* 69, 103–118

[123] Drewnowski A (2011). The contribution of milk and milk products to micronutrient density and affordability of the U.S. diet. J Am Coll Nutr. Oct;30(5 Suppl 1):422S-8S.

	environmental problems may be considerable including use of pesticides, loss of biodiversity and water use.	and sauces).		
Meat	Typically high environmental impacts across a range of indicators (GHGs, water, land use, biodiversity). However significant variation between livestock type and system. Resource efficiency role in consuming byproducts and utilising land unsuited to crop production.	Quantity consumed Species consumed Cut/format consumed (eg. carcass versus processed; lean versus fatty) Production method (intensive/extensive; grassfed/grainfed; organic/conventional	Meat can be energy and fat dense although lower fat/energy versions are available. Provides useful micronutrients. Epidemiological evidence linking meat (esp red & processed meat) to negative health outcomes although associational links in dispute. No- to moderate meat consumption compatible with health provided diets are otherwise diverse and balanced.	Source of employment and livelihoods esp for pastoralists & world's extreme poor. Animal welfare; Food security implications of feeding grain to livestock; Rural economies and landscapes Zoonoses are the leading source of emerging infectious diseases. Larger scale production system increase potential for global epidemics. Meat culturally important.
Milk & dairy	High environmental impacts across a range of indicators (GHGs, water, land use, biodiversity). Resource efficiency role in consuming byproducts and utilising land unsuited to crop production	Quantity type (milk, cheese, high fat versus low fat) Production method: intensive/extensive; grain-fed/ pasture fed Added sugar and salt	Important source of key nutrients including calcium; epidemiological evidence suggests protective effects against heart diseases. Harder to achieve good nutrition without dairy, but not impossible.	Animal welfare Food security implications of feeding grain to livestock; rural economies and landscapes Source of employment and livelihoods. Zoonoses are the leading source of emerging infectious diseases. Larger scale production system increase potential for global

				epidemics. Long working hours and low prices for UK dairy sector. Dairy foods culturally important
Fish	Stocks of many species now depleted; overfishing damages wider marine ecosystem. Unsustainable aquaculture linked to diverse environmental problems.	Omega 3 content of fish; omega three of feed inputs to aquaculture which determines Omega 3 content of farmed fish	Good source of low fat protein and other nutrients. Oily fish a key source of omega 3 fatty acids. Fish consumption linked to a range of positive health outcomes.	Fishing & aquaculture an important source of livelihoods in low income countries; EU fishing vessels undermine livelihoods & food security of artisanal African fishers, unbridled fish consumption undermines access by future generations
Fruit and vegetables	Low GHG impact produce are: robust, consumed in season or transported by sea and land. High GHG impact produce are; airfreighted, grown in heated greenhouses; reliant on irrigation. Water use a major issue for some crops (eg. citrus and tomatoes). Can be trade offs between GHG, water use & other impacts.	Organic versus non organic, seasonality, localness, transport mode, storage method; residues	Increased consumption needed. Diversity is key.	Export horticulture provides livelihoods for low income communities in developing countries. Exploitation and low wages
Sugary foods & confectionary.	Sugary foods low GHG impact to produce but occupy land area and water hungry. Often linked to pesticide use. Since nutritionally	Quantity consumed; extent to which they are consumed as substitutes for other food groups.	Source of 'empty calories' in the diet and linked to obesity and dental caries.	Source of jobs and livelihoods for millions of people worldwide Employment & livelihoods; fair trade in relation

	void represent a waste of embedded resources.			to sugar, cocoa, Culturally important.

2.5. Foods and drinks high in fat and/or sugar

From a health perspective this food group offers little nutritionally, and is often implicated in problems of obesity and associated chronic diseases.

From an environmental perspective, the issues are mixed. While sugary foods have a low GHG intensity (Audsley at al 2009, Nilsson et al 2011), [124] [125] cane sugar production is water hungry, contributing to water stress, and can also trigger clearance and habitat destruction. Maize (used to produce corn syrup) production is associated with the problems highlighted in 2.1 above. Cocoa and coffee production is also linked to deforestation and habitat loss (Gockowski and Sonwa 2011). [126] Moreover, since these foods are nutritionally 'unnecessary' and sometimes detrimental, it is arguable that their production is also unnecessary and so represents a 'waste' of embedded GHG emissions, water and land use. However this somewhat simplistic judgement underplays their cultural importance and the pleasure people obtain from these foods. Critically, it ignores the socio-economic issues involved in their production. These sectors are a source of livelihoods for millions of people world wide - some 50 and 125 million people in the case of cocoa and coffee respectively (Fairtrade Foundation 2011;) [127] - yet wages are often low and fluctuate with the season. A definition of sustainability that only considers the relationship between health and nutrition fails to do justice to these critically important dimensions.

2.6. Obesity and overconsumption

Finally, a few studies have sought to quantify the environmental impacts associated with obesity. It is argued that obesity is linked to climate change in three ways: by causing excessive food production and associated emissions, by causing unnecessary and high impact food production (specifically animal products) and by increasing transport

[124] Source: Audsley, E., Brander, M., Chatterton, J., Murphy-Bokern, D., Webster, C., and Williams, A.(2009). *How low can we go? An assessment of greenhouse gas emissions from the UK food system and the scope to reduce them by 2050.* FCRN & WWF-UK.

[125] Nilsson K, Sund V and Florén B (2011). The environmental impact of the consumption of sweets, crisps and soft drinks. SIK study comme TemaNord, Nordic Council of Ministers, Copenhagen

[126] Gockowski, Jim, and Denis Sonwa. "Cocoa intensification scenarios and their predicted impact on CO2 emissions, biodiversity conservation, and rural livelihoods in the Guinea rain forest of West Africa." Environmental Management 48, no. 2 (2011): 307-321.

[127] Fairtrade Foundation (2011). Fairtrade and Cocoa: Commodity Briefing, Fairtrade Foundation.

requirements.[128] [129] These studies, while interesting, are highly oversimplistic – for example they do not take into account the impacts of increased physical activity which could also address obesity by increasing the 'energy out' side of the equation, but would not have an impact on overall food requirements. And of course a low-calorie but very GHG intensive diet is entirely possible – for example one based around unsustainably sourced fish, airfreighted fruits and vegetables and lean meat.

2.7. Nutrition and sustainability: synergy or conflict?

The discussion above does not permit a simple answer to the question 'are nutritional and sustainability goals aligned?'- if sustainability is defined broadly to encompass not just environmental but also social and economic goals. This is not to suggest that these goals are incompatible, rather that answering this question requires **a.** better understanding of and agreement on what our social and economic goals are and **b.** how they relate to environmental and nutritional objectives. However, the evidence does enable us to broadly identify the characteristics of a lower environmental impact diet and to conclude that such a diet is generally consistent with good nutrition. The defining characteristics – which agree closely with those offered by others (see Box 2) are as follows:

- Diversity – a wide variety of foods eaten
- In energy balance
- Based around: tubers and whole grains (but not rice); legumes; fruits and vegetables - particularly those that are field grown and robust
- Dairy products or fortified plant-substitutes eaten in moderation and other calcium- containing foods also consumed
- Meat eaten sparingly – and all animal parts consumed
- Unsalted seeds and nuts included
- Some fish and aquatic products sourced from certified fisheries, although less frequently than advised by the Eatwell Plate
- Limited consumption of sugary and fatty sweets, chocolates, snacks and beverages
- Tap water in preference to other beverages

However, these broad guidelines mask several caveats, meaning there is plenty of room for disagreement. First, the production method impacts upon both the environmental and nutritional quality of the diet. The issues here are complex here and the merits of different production methods will depend on the environmental issue one chooses to prioritise.

Second, this diet is likely deliver 'good enough' rather than individually optimal nutrition –it represents a compromise position between human requirements and environmental goals. Sustainable levels of fish consumption are lower than Eatwell guidelines, while the recommendation to eat all animal parts – not just lean muscle but also offal and the fattier cuts and formats – may raise some nutritional hackles even though a sometimes higher fat content will be compensated for by substantially reduced overall intakes not just of meat but other 'high risk' foods high in sugar, fat and refined carbohydrates.

Achieving a low environmental impact diet that is compatible with health may also require greater emphasis on other non-food issues that bolster the nutritional quality of the diet: for

[128] Michaelowa, Axel; Dransfeld, Björn (2008): Greenhouse gas benefits of fighting obesity, in: *Ecological Economics*, 66, p. 298-308

[129] Edwards P and Roberts I (2009) Population adiposity and climate *change Int. J. Epidemiol*. 38 (4) : 1141-1142

example the influence of physical activity and sunlight on bone health, or the role of food fortification.

Third, these guidelines are broad; it would be misleading to put a figure on how much meat, for example, is either environmentally or nutritionally optimal, given the multiple variables discussed above. Moreover, different population groups differ in their nutritional requirements and preferences – some may need or want to eat more meat, or less than the average.

Fourth, and to reiterate the point made earlier, it is entirely possible to consume an unhealthy albeit low environmental impact diet, or vice versa. The relationship between health and environmental sustainability can best be viewed as an arranged marriage, rather than a love match.

Box 2: Published guidelines on sustainable healthy diets

Advice on consuming 'sustainably' is not new. The bestselling 1971 *Diet for a Small Planet*, argued that meat eating from a resource perspective was highly inefficient and environmentally damaging, and a raft of other books were subsequently published including Rifkin's influential *Beyond Beef* in 1992. [130] More recently a number of organisations have attempted to provide more detailed guidance on consuming healthily and yet sustainably. All of them define sustainability in environmental terms.

The Health Council of the Netherlands for example (HCN 2011)[131] provides a detailed review of the relationship between health and sustainability. It identifies areas where of synergy, of conflict, and where impacts are neutral. It finds a clear win-win in a shift to a less animal- and more plant-based diet. For the overweight, lower intakes of energy in general and in particular of confectionary-type foods would yield double benefits. The main trade off concerns fish consumption. As to 'neutral' activities, a reduction in food waste could deliver environmental benefits and have no impact either way on health.[132] Sweden's National Food Agency and the 2012 New Nordic Recommendations offer similar guidance: eat less meat, choose fish from sustainable or certified stocks, store vegetables that store well and consume perishable produce in season, eat fewer cakes etc. and minimise food waste.[133] [134]

The Italian Barilla Center has published a Double Pyramid, providing guidance on how to achieve diets that combine both health and environmental benefits. The pyramid is compatible with other forms of visual guidance on healthy eating, but this time there are two pyramids that position foods not only according to nutritional criteria but also in terms of their impact on the environment. It shows that foods with the lowest environmental impact (such as grains, pulses, fruits and vegetables) are those which offer the greatest benefits for nutritional health, while foods with the highest impact, such as red and processed meat, should, for health reasons, also be consumed sparingly. [135]

[130] Rifkin, J. (1992). Beyond beef: The rise and fall of the cattle culture. New York: Dutton.

[131] HCN (2011) Guidelines for a healthy diet: the ecological perspective. Health Council of the Netherlands, The Hague

[132] HCN (2011) Guidelines for a healthy diet: the ecological perspective. Health Council of the Netherlands, The Hague

[133] National Food Agency, undated http://www.slv.se/en-gb/Group1/Food-and-environment/

[134] Norden (2014).*Nordic Nutrition Recommendations 2012*, Nordic Council of Ministers, Copenhagen

[135] http://www.barillacfn.com/en/pyramid-introduction

Finally, a working group of the UK's Green Food project, set up by the Department for the Environment, Food and Rural Affairs, has drafted some guideline principles of a sustainable healthy diet as follows:

- Eat a varied balanced diet to maintain a healthy body weight.
- Eat more plant based foods, including at least five portions of fruit & vegetables per day.
- Value your food. Ask about where it comes from & how it is produced. Don't waste it.
- Moderate your meat consumption, & enjoy more peas, beans, nuts, & other sources of protein.
- Choose fish sourced from sustainable stocks. Seasonality and capture methods are important here too.
- Include milk and dairy products in your diet or seek out plant based alternatives, including those that are fortified with additional vitamins and minerals.
- Drink tap water
- Eat fewer foods high in fat, sugar and salt

At the time of writing these recommendations have no official status.

Conclusions

One thing is clear: the food system today is unsustainable, whether defined in narrow environmental terms or more broadly to include socio-economic dimensions.

Something needs to be done, as most people acknowledge. There is growing recognition that a shift towards 'sustainable diets' is one important approach – although this recognition is by no means widespread. At this stage however, definitions are multiple and there is no unanimous agreement of just what such a diet might look like on a plate, as it were. This is partly because stakeholders prioritise the dimensions of sustainability in different ways – but partly because there are different views on whether the status quo can and should be challenged, and how far technological advances will preclude the need for radical behaviour change. These beliefs in turn define stakeholders' different 'boundary conditions ' – their sense of what is economically, environmentally or ethically 'non negotiable.'

The boundary condition for many environmental NGOs and researchers, is the reality of absolute environmental limits. We broach these at our peril. The task therefore, is to shrink our consumption patterns to fit the 'safe operating space' available for humanity (Rockström et al, 2009).[136] This points to the need for fairly drastic changes, and in particular to a reduced consumption of animal products. As to the nutritional implications, since their focus is generally on issues of excess they focus on problematic macro-nutrients (energy, fat) rather than on the micronutrients (iron, zinc, calcium) associated with insufficiency. From this perspective lower meat diets are seen as actively beneficial to health: win wins are possible.

[136] Rockström, J., W. Steffen, K. Noone, Å. Persson, F. S. Chapin, III, E. Lambin, T. M. Lenton, M. Scheffer, C. Folke, H. Schellnhuber, B. Nykvist, C. A. De Wit, T. Hughes, S. van der Leeuw, H. Rodhe, S. Sörlin, P. K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R. W. Corell, V. J. Fabry, J. Hansen, B. Walker, D. Liverman, K. Richardson, P. Crutzen, and J. Foley. (2009). Planetary boundaries:exploring the safe operating space for humanity. *Ecology and Society* 14(2): 32. [online] URL: http://www.ecologyandsociety.org/vol14/iss2/art32

An alternative approach dismisses this view, wholly or in part, as Malthusian doom-mongering, highlighting technology's success to date in extricating humanity from difficult situations. For stakeholders with this view, environmental limits are elastic rather than rigid. With ingenuity we can create a 'safe operating space' that, Tardis-like, is bigger on the inside than out, thereby permitting today's patterns of consumption while also addressing environmental concerns. For them, the circumscribing boundary conditions are the workings of the global economy and the inevitability of rising demand. While changes may be possible at the margins (product reformulations to improve nutritional quality, improved consumer awareness, a better balance of fiscal incentives and disincentives) fundamentally it is the economic and societal status quo, rather than natural limits, that are immutable.

Faced with these different framings of the issue, is it possible to draw any meaningful conclusions? To a certain extent, it is. For a start, a growing body of interdisciplinary evidence concludes that it is possible to devise diets that **a.** generate lower environmental impacts than the consumption average and that are **b.** broadly in line with current nutritional guidelines. The lower the meat, fish and dairy content, the lower the environmental impact - and the more important it will be that reduced meat intakes are compensated for with increases in the quantity and diversity of whole grains, fruits and vegetables, and legumes.

Such a diet may compromise on certain nutritional ideals but it certainly represents a significant improvement on the quality of the average British diet today. However not everyone likes compromises. Disagreements are likely to continue as to whether nutritional guidance should prioritise societal over individual objectives; the needs of people today and in this country, over generations tomorrow and in other countries; the legitimacy of measures such as GM and fortification strategies in compensating for deficits; and the relative importance assigned to non-nutritional determinants of health. Critically, there will be strong disagreement as to whether people can actually be persuaded to eat like this, and if persuasion is not possible, what level of coercion (through prices, regulations and so forth) might be legitimate or effective.

Moving beyond a narrow environmental focus, we know far less about the complex relationship between nutritional objectives, environmental sustainability and our other social and economic goals. This is partly because most of the work on sustainable diets has been driven by the environmental agenda – understandably so, in view of the massive environmental problems we face. However it also reflects the fact that social and economic objectives are extremely hard to agree upon. For example: food should be affordable, but does that mean that cheap food is good? Is small scale or large scale production to be preferred? Is equality an end in itself or can its pursuit stifle innovation? There may well be synergies between nutritional adequacy, environmental sustainability and certain economic goals, but there are also likely to be costs and deciding how they should balanced between the two depends on one's ideological position. What is more, some economic benefits are only likely to ensue if certain changes are made to the workings of the economy – and there will be disagreements as to how far that is possible.

Finally, this chapter has been as much about values as about 'science.' While scientific knowledge – including in the fields of nutrition and the environment - may be important, the meaning people assign to its insights will be influenced by beliefs about what is right and wrong, about how the world works and how it ought to work. Any discussion of sustainability and which we should go, has to take into account, and explore, the values that stakeholders bring to the debate.

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