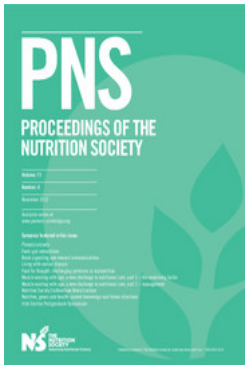

Is a healthy diet an environmentally sustainable diet?

Jennie I. Macdiarmid

Proceedings of the Nutrition Society / *FirstView* Article / November 2012, pp 1 - 8
DOI: 10.1017/S0029665112002893, Published online:

Link to this article: http://journals.cambridge.org/abstract_S0029665112002893

How to cite this article:
Jennie I. Macdiarmid Is a healthy diet an environmentally sustainable diet?. Proceedings of the Nutrition Society, Available on CJO doi:10.1017/S0029665112002893

Proceedings of the Nutrition Society, Page 1 of 8 doi:10.1017/S0029665112002893

A Meeting of the Nutrition Society, hosted by the Scottish Section, was held at King's College Conference Centre, University of Aberdeen on 26–27 March 2012

Conference on 'Future food and health'
Symposium I: Sustainability and food security

Is a healthy diet an environmentally sustainable diet?

Jennie I. Macdiarmid
Public Health Nutrition Research Group, Rowett Institute of Nutrition and Health, University of Aberdeen, Aberdeen AB25 2ZD, UK

The concept of a healthy and environmentally sustainable diet is not new, but with increasing concern about future global food security and climate change there is a renewed interest in this topic. Dietary intakes in UK accounts for approximately 20–30% of total annual greenhouse gas emissions (GHGE), with the greatest contributions coming from high intakes of meat and dairy products. Dietary proposals to help mitigate climate change (i.e. reduce GHGE) have focused on reducing consumption of meat and dairy products, but this must be considered in the context of the whole diet, alongside any possible nutritional consequences for health. Bringing together health and environmental impact of the diet raises the question of whether a healthy diet can also be an environmentally sustainable diet. While recent research showed that it is possible to achieve a realistic diet that meets dietary requirement for health and has lower GHGE, it cannot be assumed that a healthy diet will always have lower GHGE. With different combinations of food it is possible to consume a diet that meets dietary requirements for health, but has high GHGE. It is important to understand what constitutes a sustainable diet, but this then needs to be communicated effectively to try and change well-established dietary intakes of the population. Studies show that understanding of sustainable diets is poor and there are many misconceptions (e.g. the overestimation of the protein requirements for a healthy diet), which could contribute to the barriers towards changing dietary intakes.

Dietary requirements: Health: Greenhouse gas emissions: Sustainable diets

Concern about future global food security and climate change has led to renewed interest in the concept of sustainable, healthy diets. In the past few years, a number of UK government reports have been published that describe the importance of the environmental impact of the diet and the contribution different foods make to climate change[1–4]. In 2011, the UK government published a national food strategy, Food 2030, which stated 'there are big challenges today which means we need to think differently about food'. The report's authors singled out climate change and obesity as two of the biggest challenges facing society today[2] and given some of the synergies between these two areas proposed that they could be considered together in terms of sustainable diets.

The concept of a sustainable diet is not new. In 1986, Gussow & Clancy[5] proposed that dietary guidelines should take into account sustainability and the impact of dietary patterns on global natural resources. The authors[5] cite work from the 1920s which proposed that these were important issues for designing dietary guidelines, and which are not dissimilar to those we still face today; save energy, reduce food waste, limit meat consumption and use local food. More recently experts from public health nutrition have called for an expansion of food and nutrition policy to encompass environmental sustainability (i.e. Giessen Declaration, 2005)[6]. Integrating guidance to reduce the environmental impact of the diet with dietary recommendations for health adds a level of complexity

Abbreviations: GHGE, greenhouse gas emissions.
Corresponding author: Dr Jennie I. Macdiarmid, fax +44 1224 437285, email j.macdiarmid@abdn.ac.uk

but addressing these issues together is essential to ensure clear and consistent dietary messages are given to consumers.

It is important, however, to understand what is meant by 'sustainable diets/food' because 'sustainable' has different meanings depending on the context. A sustainable diet can have many different dimensions such as health, environment, economics and social influences, and the complexity of defining this term was captured in the 2010 Food and Agriculture Organization definition; '... those 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'[7]. These attributes are not independent; for example health can depend on the affordability and access to good quality of food, and the quality of the food can depend on the land and soil in which it is produced (i.e. environment). Given the complex nature of the term it is important in any discussion of sustainable diets to be clear which elements are being referred to and the context in which it is being used. In this paper 'sustainable diets' refers to the impact of the diet on health and the environment, specifically greenhouse gas emissions (GHGE) relating to climate change.

In terms of health, the UK population is failing to meet national dietary recommendations, with intakes of SFA, non-milk extrinsic sugars and salt above the maximum recommendations, and intakes of fibre and some micro-nutrients below the minimum recommendations[8]. Low intakes of Fe are a particular concern among women and teenage girls, where 22 and 44% respectively have intakes below the lower reference nutrient intake. The National Diet and Nutrition Survey and the Living Cost and Food Survey[9] both show that only a very small change in dietary patterns in the last decade. These poor dietary habits are reflected in the general health of the population; for example over 60% of adults and 30% of children in the UK are overweight or obese[8]. The challenge still remains to change the dietary intake of the population to improve health, but now future policy and recommendations need to also consider the environmental impact of dietary choices. Recommendations need to be integrated to ensure a consistent message is given to consumers, and to avoid any unintended consequences of an action in one area to the detriment of another area[10].

A question that has arisen is whether a healthy diet is an environmentally sustainable diet. Although with the right combination of foods it has been shown that it is possible[11], it cannot be assumed that a healthy diet will always be one with a lower environmental impact. It is equally possible to have a diet that meets dietary requirements but has a high environmental impact. The aim of this paper is to address this question in more detail, as well as explore some of the challenges to change dietary intakes and the complexities of integrating health and environmental issues for a sustainable diet.

Contribution of food choices to climate change

Food and dietary choices can have an impact on the environment in many ways, such as climate change, land, water and energy use, and biodiversity, but the focus of this paper is on climate change, specifically GHGE. Climate change is the result of the emission of greenhouse gases into the atmosphere which causes global warming[12]. Greenhouse gases, defined under the Kyoto protocol, include CO_2, CH_4, N_2O and refrigerant-type gases (e.g. hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride), and are collectively known as CO_2 equivalents[13]. These gases vary in their impact on global warming, with CH_4 being about twenty-five times more potent, N_2O 296 times more potent and the refrigerant gases being many thousands of times more potent than CO_2. Some of these gases do occur naturally, but the increase in the global temperature seen in the past century correlates to an equally dramatic rise in GHGE resulting predominantly from human activities[12].

There is an urgent global need to mitigate GHGE to limit further climate change but at the same time address the challenges of food security and an increasing global population with finite natural resources. Beddington described the future food security scenario of climate change, diminishing water and energy resources and the increasing population and urbanisation as the 'perfect storm' of global events, and '...that by 2030 the world will need to produce around 50% more food and energy, together with 30% more fresh water, whilst mitigating and adapting to climate change.'[14]. The UK passed the Climate Change Act in 2008, which set legally binding targets to reduce GHGE by 80% by 2050, with an interim target of 34% by 2020 (targets are set against 1990 emission levels)[15]. Similar legislation was passed in Scotland in 2009, but with a higher interim reduction target of 42% by 2020. These targets provide a clear message that action is needed, but they are production-based emission targets (include only goods and services produced within the UK) and do not include goods and services imported into the UK, which is particularly important when considering the GHGE of the diet. For example, the UK imports approximately twice as much beef as it exports but the imported meat consumed in the UK is not counted in the UK GHGE production targets. For the true impact of the diet it is important that the total GHGE is based on food consumed in the UK, not just food produced in the UK.

It is estimated that the food supply chain accounts for approximately 18–20% of the annual GHGE in the UK (consumption-based emissions), with meat and dairy products having the highest contribution to these emissions[16]. This increases to more than 30% if land use change is included[17]. GHGE occurs at every stage of the food chain (referred to as the lifecycle of a product) from agricultural production through to consumption and disposal of waste food. Figure 1 shows a simplified version of where emissions occur across the life cycle, as well as where nutritional changes can occur, which can be used to identify where GHGE can be reduced or nutritional quality improved. Reductions in GHGE are being made at the food production stage (e.g. agriculture, production methods,

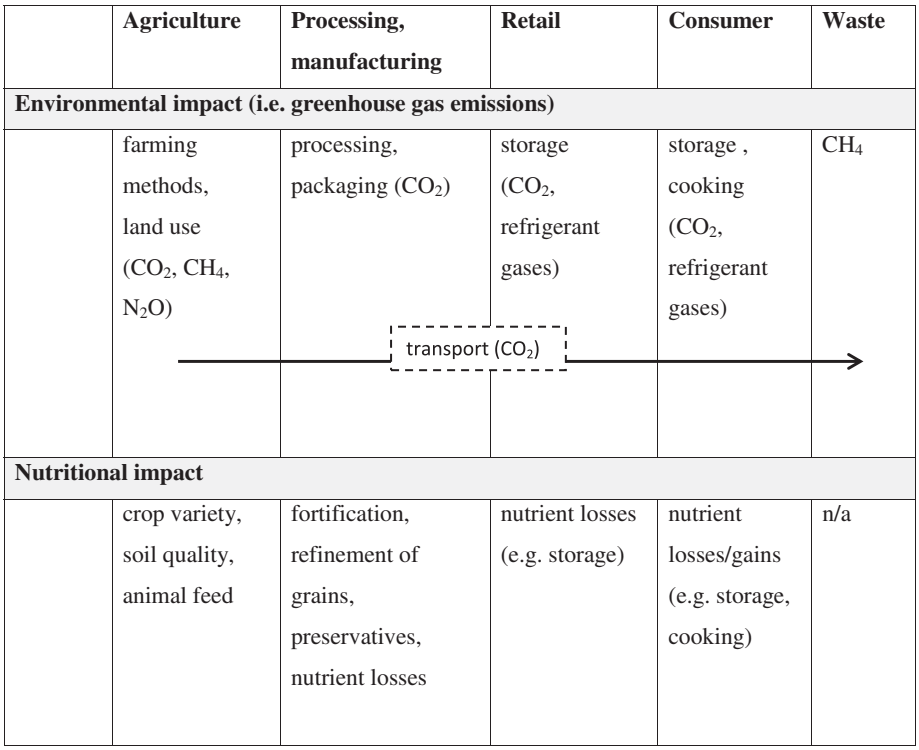

Fig. 1. Environmental impact of food and nutritional changes throughout the food chain.

transportation and reduction of waste), but there are practical limitations beyond which it is impossible still to produce food. Consumers therefore also need to play a significant role in the reduction of GHGE through modification of their dietary patterns and food choices.

Variation in greenhouse gas emissions by food groups

GHGE vary significantly between different foods groups, but also within food groups. Despite the uncertainties in estimating GHGE, the general hierarchy of the GHGE for the broad food groups is accepted to be relatively consistent; animal-based products tend to have higher emissions than plant-based foods (by weight of food). GHGE can, however, vary quite significantly for the same food depending on farming methods (e.g. intensive *v.* extensive), geographic region (e.g. UK *v.* other countries), transport method (e.g. air freighted *v.* shipped) and the growing conditions (e.g. outdoors *v.* heated glass houses)[16]. For example, it is estimated that tomatoes produced in the UK in heated glasshouses using fossil fuels can have a GHGE 5–6 times higher than those produced outdoors in Spain and transported by road to the UK[17]. Similarly meat from intensively reared livestock can have lower GHGE because of the faster rate of growth of the animal and therefore a shorter lifetime (less CH_4 and manure produced). There are obviously other issues such as animal welfare, water use (e.g. using irrigation systems in water scarce area), and economic viability (e.g. extending production beyond the natural growing season by using heated glasshouses) that need to be taken into consideration.

The highest GHGE are associated with ruminant animals due to CH_4 produced during digestion and N_2O from the manure, and both of these gases are much more potent than CO_2[16]. Using national dietary surveys it has been shown that meat and meat products are consistently the most significant contributors to GHGE in the diet in many developed countries[18–20]. These observations have driven recommendations to reduce intakes of meat and dairy products in order to lower the GHGE, but these types of changes must consider the nutritional implications and ensure that there are no detrimental consequences for the health, e.g. Fe or Zn status. Equally, any proposed changes needs to be realistic in terms of acceptability and cost if they are to have any prospect of achieving dietary changes. Given that less than 2% of the UK population report being vegetarian, and even fewer being vegan[8], it would be unrealistic to suggest a meat-free diet.

Is a healthy diet an environmentally sustainable diet?

There is not a simple answer to this question because of one of the fundamental differences between defining a healthy diet and a diet with a low environmental impact. A healthy diet is principally about the nutrient intakes, which can be achieved from many different combinations of foods. In contrast, GHGE are associated with food items for which the nutrient content can vary. Taking for example protein, there are dietary reference values for minimum intakes of protein, and this can come from animal- or plant-based proteins, but the choice made will vary significantly in terms of GHGE. This is the same even for food-based dietary recommendations, such as fruit or

vegetables which can have very different GHGE depending on the product selected. In that sense it cannot be assumed that a healthy diet meeting nutrients requirements will necessarily have low GHGE as it will depend on the specific foods in the diet.

One of the first studies to investigate whether it was possible to have a realistic diet that met dietary requirements for health and minimise the GHGE from the diet showed that it was possible to meet recommendations for energy and macro- and micronutrients[21] while selecting foods that would minimise the GHGE of the diet (approximately a third lower)[11–20]. This was achieved without eliminating meat and dairy products from the diet, although the quantity of meat was reduced considerably compared with current intakes reported in the National Diet and Nutrition Survey, and the type of dairy products tended to be reduced fat versions. It was possible to create diets with even lower GHGE (up to 90% reduction) while still achieving dietary requirements but the range and quantities of foods were completely unrealistic (i.e. only seven food items and all in unrealistic quantities). This study demonstrated that a healthy diet can be compatible with one that is significantly lower in GHGE.

This, however, should not be interpreted that a healthy diet will always have lower GHGE. Using the 'healthy, low GHGE' diet described earlier[20] comparator diets were created by swopping the food items for ones higher in GHGE or for less healthy items while maintaining the same dietary pattern and total energy intake (Table 1). It was possible to create a diet that met dietary requirements but had almost double the GHGE by using fruit and vegetables with high GHGE, rice rather than pasta or potatoes (rice produces CH_4) and increasing the amount of red meat (not exceeding the maximum recommended intakes). Conversely, it was possible to create a diet very low in GHGE based on high intakes of sugar and refined carbohydrates, with only small amounts of meat, fruit and vegetables ('unhealthy, high GHGE'). Finally, a diet was created with a high meat and protein content, and only small amounts of complex carbohydrates, fruit and vegetables which was very high in GHGE and did not meet dietary requirements ('unhealthy, high GHGE'). These are only examples of diets, but they serve to illustrate that it cannot be assumed a healthy diet will be lower in GHGE. Population studies have shown that distribution of GHGE coming from individual dietary intakes is very wide[18,23].

Changing dietary patterns and food choices for health and the environment

As we move closer to understanding some of the principles of a healthy and lower environmental impact diet, the challenge is to change dietary patterns and food choices of the population. Historically, attempts to improve dietary intakes have been relatively unsuccessful despite the positive impact of a healthy diet for an individual. Changing dietary intakes to limit the damage to the environment is likely to prove even more challenging, particularly as there is no obvious immediate personal gain. A recent study exploring different 'pro-environmental behaviours' (behaviours included: limiting the number of flights taken; recycling; reducing food waste; reducing energy use; installing insulation; eat more local/seasonal food; limit water usage; use cars less for short trips; use vehicles more efficiently renewable energy systems) showed that adopting a lower environmental impact diet was a change people thought they were most able to make, but it was the change they were least willing to make (<10% population sample)[24]. Another survey of 3000 adults in the UK revealed that only 15% of people would change their diet for the benefit of the environment[25]. Interestingly, in contrast they said that were more willing to cut down the amount of red meat in their diet than reduce their intake of dairy products (63% *v.* 45%), but putting this into context 76% said they would be willing to reduce their consumption of confectionery.

The concept of a sustainable diet is complex and therefore open to misinterpretations. Studies suggest that there is a relatively high awareness among the population that food production has an impact on climate change (56%), but <20% of respondents said that they would know how to change their diet to one that is more sustainable[25]. The most commonly cited diet-related behaviours that people think would be beneficial to the environment are avoiding excessive packaging, purchasing locally produced food, eating organic food and reducing food waste[26,27]. Significantly fewer people think changing their diet could have an impact. Lea & Worsley[26] reported that >85% of people thought that using less packaging and purchasing locally produced food would benefit the environment, compared with only 22% who thought that eating less meat would be beneficial. Similarly, Tobler *et al.*[27] reported that people rated eating less meat to have the least benefit to the environment. This suggests that there is scope to provide information, but at the same time recognising that this is unlikely to be sufficient to change behaviour.

Dietary changes that could benefit both the health of the population and the environment

Two proposals to reduce GHGE are to reduce intakes of meat (and dairy products) and to reduce overconsumption by only eating sufficient energy required to maintain a healthy weight[4,16]. These could both have benefits for health and the environment.

Reducing intakes of meat and meat products

Moving towards a more plant-based diet could have benefits for health and the environment, but changing well-established dietary habits dominated by animal-based products will not be easy. In the UK, the consumption of meat and meat products is steadily increasing[8,9], with the increase in consumption of animal protein far outstriping that of plant-based protein; between 1990 and 2006 protein intake from animal sources increased by 11%, while plant-based protein increased by 5%[24]. Several studies have explored attitudes towards reducing the intake of meat and much of the resistance towards this relates to the pleasure

Table 1. Scenarios to illustrate the variation in greenhouse gas emissions (GHGE)** of achievable healthy diets that meet nutrient requirements and unhealthy diets that fail to meet nutrient requirements

	Dietary requirements for a woman*	Healthy low GHGE	Healthy high GHGE	Unhealthy low GHGE	Unhealthy high GHGE
Diet description		Balance of meat, fish, dairy and fruit/vegetables	High in meat and fruit/vegetables	High in sugar food and drinks; low in meat and fruit/vegetables	High in meat and sugar food and drinks; low in fruit/vegetables
Energy (MJ/d)	8·7	8·7	8·7	8·7	8·7
Total fat (% energy)	⩽35	30·8	31·5	37·3	35·0
Saturated fat (% energy)	⩽11	8·8	9·9	15·0	13·7
Total carbohydrate (% energy)	⩾50	56·2	54·3	54·7	48·1
Non-milk extrinsic sugars (% energy)	⩽11	8·4	8·9	24·0	13·7
Protein (g/d)	⩾45	84	89	57	101
Non-starch polysaccharides (g/d)	⩾18	25	19	10	11
Na (mg/d)	⩽2400	2328	2132	2336	2774
Fe (mg/d)	⩾14·8	16·0	15·3	9·8	14·8
Total meat (red/processed) (g/d)	⩽70 red meat	53 (27)	96 (70)	66 (66)	212 (162)
Eatwell plate proportions					
Starchy foods (%)	33	32	29	16	18
Fruit and vegetables (%)	33	33	34	4	15
Dairy (%)	15	14	14	17	12
Protein foods (%)	12	12	14	13	38
High fat/high sugar (%)	8	9	9	50	17
GHGE ($kgCO_2e/d$)**	–	2·44	4·56	1·97	4·37

*SACN Dietary Reference Values for Energy[22] and Department of Health Dietary Reference Values for an adult woman[21].
**GHGE include only up to the point of the regional distribution centre (not full lifecycle analysis) but are adjusted for the food as eaten.

people experience from eating meat (e.g. taste) and the opinion that a 'proper' meal should include meat[28,29]. To a lesser extent people report a lack of knowledge about food that could be eaten in place of meat or that a plant-based diet would not contain enough protein (a view more commonly expressed among men than women). This is an interesting and important observation.

Relatively very few people in developed countries consume less than the dietary requirement for protein. In the UK, the average intake of protein exceeds requirements, with a mean daily intake of protein for men and women of 88·1 and 65·4 g, respectively[8] (dietary reference values are 55 and 45 g/d[21]). Actual intakes are likely to be higher given dietary under-reporting in dietary surveys. High intakes of protein are not unique in the UK; US dietary surveys show a similar pattern, reporting that fewer than 3 % of adults consume less than their estimated average requirement[30]. Despite these higher than adequate intakes there is a perception among a significant proportion of the population that they should be eating more protein. In the USA 49 % of respondents of a recent national survey reported that they were trying to increase the amount of protein in their diet[31].

It is not clear where this misconception about the amount of protein required for a healthy diet originated, but it could have been exacerbated by the focus on high protein and low carbohydrate diets, popularised by the media for weight loss. In a recent study assessing knowledge of healthy diets (based on the Eatwell plate proportions) over 80 % of respondents correctly identified the recommended proportion of fruit/vegetables, dairy products and high fat/sugar foods for a healthy diet[32]. The majority of people (>65 %), however, confused the amount of starchy carbohydrate foods and protein foods recommended for a healthy diet. Participants thought that protein should make up approximately one-third of the diet while starchy foods only about 12 % (when the reverse is true for a healthy diet). Starchy foods are often perceived by the public and some health professionals as 'fattening' and they should be restricted[33], which is reinforced by promotions of 'low carb' diets. These beliefs need to be changed as they pose a significant barrier to achieving a healthy and sustainable diet.

Reducing the consumption of meat and meat products would lower GHGE, but the magnitude of reduction in GHGE depends on the foods that replace them in the diet. Berners-Lee *et al.*[34] created a number of dietary scenarios that showed a reduction of 18–31 % in GHGE could be achieved by replacing meat with a variety of different foods. The diet with the lowest GHGE had almost a third more 'added sugar' than the other diet scenarios because sugar tends to have lower emissions than many other foods. It was also the cheapest diet. Similarly, Vieux *et al.*[18] modelled the dietary intake of the French population based on reducing meat intake. Reducing meat to 50 g/d reduced the GHGE by 12 % without replacement of energy; however, iso-energetic replacement of the meat with fruit/vegetables actually increased GHGE by 2·7 % as the quantity of fruits/vegetables required to replace the energy value of meat negated any reduction in GHGE. Typically GHGE are expressed as kg CO_2e/kg food

product and by this definition meat and meat products have higher GHGE than fruit and vegetables. Expressed GHGE as kg CO_2e/kJ energy of the food, however, means that some fruit and vegetables have higher GHGE than meat (due to the energy density). These studies serve to highlight the importance of considering the whole diet rather than single food items and the nutritional and environmental impact of substituted foods. These were based on modelling dietary scenarios but future research needs to explore what substitutions people are willing to make in real life and the consequences of this for health and GHGE.

Impact of overconsumption on health and environmental sustainability

Limiting energy intakes across the population to an amount that is required to maintain a healthy body weight has been proposed as another way to reduce GHGE, and at the same time this could address the obesity epidemic[4]. Over 60% of adults and a third of children in the UK are overweight or obese suggesting that for the majority of the population energy intake is exceeding energy needs. At a population level there is a relatively strong correlation between energy intake and GHGE (r 0·57)[18], but as discussed earlier focusing on simply reducing energy intakes will not necessarily ensure a reduction in GHGE as it will depend on the types of food in the diet. For example if a high protein, low carbohydrate-based diet were adopted this may help restrict energy intake, but is unlikely to reduce GHGE if the diet is high in meat and dairy products.

Overconsumption and obesity could be viewed as a form of food waste in terms of consuming more food than required thereby placing more demand on food production (high GHGE), with consequences for global food security. Various authors have suggested that in addition to contributing to GHGE through excessive food consumption, obesity can impact indirectly through the increased physical mass of overweight or obese individuals[35–37]. Some studies have estimated additional fuel costs in terms of GHGE of transporting heavier people by motorised transportation[38], others have estimated the savings global weight loss could have in terms of respired CO_2 (the amount of respired CO_2 is proportional to body mass)[35]. Grykavv *et al.*[35] estimated that a 10 kg sustained weight loss among all obese globally could reduce emissions by 0·2% based on a reduction in respired CO_2 alone. A potential limitation of this study, however, was that the weight loss diet was based on a six-month high protein, low-carbohydrate diet, which was not factored into the GHGE calculation. In absolute terms, these are very small reductions in GHGE and it will require many lifestyle changes to achieve a significant reduction in GHGE. Other mutually beneficial activities could be to increase physical activity by reducing motorised transport or reducing sedentary activity (e.g. screen time) which could reduce GHGE through reducing energy use[38] and have a positive impact on health. These actions are hypothesised and would need to be monitored in practice to identify if there are any rebound substitution effects, which would negate positive outcomes. Obesity is a good example of a health problem that could be addressed through both health and environmental policy together, but it is important to find other connections and policy drivers to address these problems together.

Where are the potential conflicts between health and the environment?

Tackling obesity and reducing intakes of meat have potential co-benefits for health and the environment, but this is not the case for all aspects of the diet. The most widely recognised conflict between health and environmental sustainability is the dietary recommendation for fish intake. Fish is recognised as a good source of protein and oily fish are high in *n*-3 fatty acids, which forms the basis for the current recommendation of two portions of fish per week (one of which should be oily fish)[39]. The issue is whether the current and future stocks of fish are sufficient if the population were to eat their recommended intake of oily fish, which they currently do not meet[8]. Technological solutions (e.g. aquaculture) are being sought to increase the supply of fish and developing aquaculture has been suggested as one of the potential actions for future global food security[40]. Efforts to increase fish supplies as a source of sustainable protein, however, need to be done in conjunction with encouraging more people in the UK to eat fish as part of their diet. The average intake of fish among adults in the UK is only 58 g/week, which is equivalent to about 41% of the recommended intake, with many people eating no fish at all[8]. There is also confusion among consumers about the sustainability of eating fish, despite the introduction of labelling of fish from sustainable sources and media campaigns[41]. This is a good example of where a single consistent message about health and the sustainability of foods is needed otherwise the consumers will simply disengage.

Other more subtle conflicts can arise as a result of dietary recommendations for a healthy diet. In the dairy sectors for example, GHGE are relatively high compared with plant-based foods but dairy products can provide essential nutrients in the diet. However, they also contribute significant quantities of SFA and therefore consumers are recommended to eat lower fat dairy products. The majority of the population adheres to this, with only 20% of the adult population consuming whole milk[8]. Removing the cream from dairy products creates an economic dilemma for producers and an environmental issue in terms of food waste if it cannot be used elsewhere. For health, it is counterproductive if all of the fat removed simply re-enters the diet in the form of other processed foods (e.g. ice-cream, cakes and ready meals). So, the question is how can this type of by-product be used for non-dietary purposes without creating a negative environmental impact? In the meat industry, there are similar issues for food waste if we only consume the lean meat from the animal and not the entire animal (e.g. offal). Duchin[42] draws attention for the need to factor in the environmental impact of increasing production of fruit and vegetables to supply the recommended intake of five-a-day, given the water and climatic constraints in many countries supplying these

NS Proceedings of the Nutrition Society

products and the seasonality for fresh produce. These examples serve only to illustrate the potential of unintended consequences if the food and dietary recommendations for health and the environment are considered in isolation and highlight the importance for working together.

Summary

Returning to the question posed at the start, 'Is a healthy diet an environmentally sustainable diet?' this paper has attempted to show the complexity of the answer and illustrated that general assumptions cannot be made. The discussion focused on GHGE and climate change, but it is important to return to the Food and Agriculture Organization definition of a sustainable diet and can consider the other environmental, social and economic elements. Understanding about the environmental impact of food choices is increasing but the major challenge remains to change the current unhealthy and unsustainable dietary patterns of the UK population that have become well established over decades. It is recognised that substantial changes will also need to be made to agricultural and food industry practices to change the food environment, but this should not be seen as an alternative to individuals changing their dietary patterns as action is needed in all sectors[42]. Furthermore, to tackle this immense problem will require working together across disciplines, and as proposed by Godfray *et al.* when he referred to tackling these issues in terms of food security: 'Navigating the storm will require a revolution in the social and natural sciences concerned with food production, as well as a breaking down of barriers between fields.'[40]

References

1. UK Cabinet Office Strategy Unit (2008) *Food Matters: Towards a Strategy for the 21st Century*. London: HM Government.
2. Department for Environment, Food and Rural Affairs (2010) *Food 2030*. London: HM Government.
3. Foresight, The Future of Food and Farming (2011) Final Project Report. London: The Government Office for Science.
4. Sustainable Development Commission (2009) Setting the Table: Advice to Government on Priority Elements of Sustainable Diets. http://www.sd-commission.org.uk/data/files/publications/Setting_the_Table.pdf (accessed August 2012)
5. Gussow J & Clancy K (1986) Dietary guidelines for sustainability. *J Nutr Educ* **18**, 1–5.
6. Anonymous (2005) The Giessen Declaration. *Public Health Nutr* **6A**, 783–786.
7. Food and Agriculture Organization of the United Nations (2010) *International Scientific Symposium. Biodiversity and Sustainable Diets – United Against Hunger*. Rome: FAO Headquarters.
8. Bates B, Lennox A, Bates C *et al.* (2011) *National Diet and Nutrition Survey: Headline Results from Years 1 and 2 (Combined) of the Rolling Programme 2008/09–2009/10*. London: Department of Health.
9. Horsfield G (2011) Family Spending: A Report on the 2010 Living Costs and Food Survey. London: UK Office for National Statistics.
10. Millward D, Garnett T (2010) Plenary Lecture 3: Food and the planet: nutritional dilemmas of greenhouse gas emission reductions through reduced intakes of meat and diary foods. *Proc Nutr Soc* **69**, 103–118.
11. Macdiarmid JI, Kyle J, Horgan GW *et al.* (2012) Sustainable diets for the future: can we contribute to reducing greenhouse gas emissions by eating a healthy diet? *Am J Clin Nutr* **96**, 632–639.
12. Intergovernmental Panel on Climate Change (1990) *Climate Change: The IPCC Scientific Assessment*. Cambridge: Cambridge University Press.
13. United Nations (1998). *Kyoto protocol to the United Nations Framework Convention on Climate Change*. United Nations http//unfcc.int/kyoto_protocol/items/2830.php (accessed November 2012).
14. Beddington J (2009) *Food, Energy, Water and the Climate: A Perfect Storm of Global Events?* London, UK: Government Office for Science. http://www.bis.gov.uk/assets/goscience/docs/p/perfect-storm-paper.pdf (accessed August 2012)
15. HM Government (2008) *Climate Change Act*. London: HMSO.
16. Garnett T (2008) Cooking Up a Storm: Food, Greenhouse Gas Emissions and Our Changing Climate. Surrey: University of Surrey, Food Climate Research Network, Centre for Environmental Strategy.
17. Audsley E, Brander M, Chatterton J *et al.* (2009) How low can we go? An Assessment of Greenhouse Gas Emissions from the UK Food System and the Scope for Reduction by 2050. WWF-UK.
18. Vieux F, Darmon N, Touazi D *et al.* (2012) Greenhouse gas emissions of self-selected individual diets in France: changing the diet structure or consuming less? *Ecol Econ* **75**, 91–101.
19. Wallen A, Brandt N & Wennersten R (2004) Does the Swedish consumer's choice of food influence greenhouse gas emissions? *Environ Sci Policy* **7**, 525–535.
20. Macdiarmid JI, Kyle J, Horgan G *et al.* (2011) Livewell: A Balance of Healthy and Sustainable Food Choices. WWF-UK.
21. Department of Health (1991) *Dietary Reference Values for Food Energy and Nutrients for the United Kingdom*. London, UK: HMSO.
22. Scientific Advisory Committee on Nutrition (2001). *Dietary Reference Values for Energy*. London: The Stationery Office; http://www.sacn.gov.uk/pdfs/sacn_dietary_reference_values_for_energy.pdf (accessed August 2012).
23. Coley D, Goodliffe E & Macdiarmid J (1998) The embodied energy of food: the role of diet. *Energy Policy* **26**, 455–459.
24. Department for Environment, Food and Rural Affairs (2008) *A Framework for Pro-environmental Behaviours*. London: HMSO; http://archive.defra.gov.uk/evidence/social/behaviour/documents/behaviours-jan08-report.pdf. (accessed August 2012)
25. Department for Environment, Food and Rural Affairs (2011) Attitudes and Behaviours around Sustainable Food Purchasing. Report (SERP 1011/10)
26. Lea E & Worsley A (2008) Australian consumers' food-related environmental beliefs and behaviours. *Appetite* **50**, 207–214.
27. Tobler C, Visschers VH & Siegrist M (2011) Eating green. Consumers' willingness to adopt ecological food consumption behaviors. *Appetite* **57**, 674–682.
28. Lea EJ, Crawford D & Worsley A (2006) Public views of the benefits and barriers to the consumption of a plant-based diet. *Eur J Clin Nutr* **60**, 828–837.

NS Proceedings of the Nutrition Society

29. Schösler H, de Boer J & Boersema JJ (2012) Can we cut out the meat of the dish? Constructing consumer-oriented pathways towards meat substitution. *Appetite* **58**, 39–47.
30. Fulgoni VL (2008) Current protein intake in America: analysis of the National Health and Nutrition Examination Survey. *Am J Clin Nutr* **87**, 1554S–1557S.
31. International Food Information Council Foundation (2010) Food and Health Survey: Consumer Attitudes Toward Food Safety, Nutrition & Health. http://www.foodinsight.org/Content/3651/2010FinalFullReport.pdf (accessed August 2012)
32. Prior G, Hall L, Morris S & Draper A (2011) Exploring food Attitudes and Behaviours in the UK: Findings from the Food and You Survey 2010. Food Standards Agency. http://www.foodbase.org.uk//admintools/reportdocuments/641-1-1079_Food_and_You_Report_Main_Report_FINAL.pdf (accessed August 2012)
33. Chan V, Eunson J, Murray L *et al.* (2012) Investigating How Both Consumers and Health Professionals Understand Healthy Eating Messages. Food Standards Agency Scotland. 'http://www.foodbase.org.uk//admintools/reportdocuments/753-1-1294_FS244029_1_Ipsos-_FINAL.pdf (accessed August 2012)
34. Berners-Lee M, Hoolohan C, Cammack H *et al.* (2012) The relative greenhouse gas impacts of realistic dietary choices. *Energy Policy* **43**, 184–190.
35. Gryka A, Broom J & Rolland C (2012) Global warming: is weight loss a solution? *Int J Obes* **36**, 474–476.
36. Egger G (2008) Dousing our inflammatory environment(s): is personal carbon trading an option for reducing obesity and climate change? *Obes Rev* **9**, 456–563.
37. Edwards P & Roberts I (2009) Population adiposity and climate change. *Int J Epidemiol* **38**, 1137–1140.
38. Michaelowa A & Dransfeld B (2006) Greenhouse Gas Benefits of Fighting Obesity. Hamburg Institute of International Economics (HWWI). http://www.hwwi.org/uploads/tx_wilpubdb/HWWI_Research_Paper_4-8.pdf (accessed August 2012)
39. Department of Health (2011) The Eatwell Plate. http://www.dh.gov.uk/en/Publichealth/Nutrition/DH_126493 (accessed August 2012)
40. Godfray HCJ, Beddington JR, Crute IR *et al.* (2010) Food security: the challenge of feeding 9 billion people. *Science* **327**, 812–818.
41. Clonan A, Holdsworth M, Swift J *et al.* (2011) The dilemma of healthy eating and environmental sustainability: the case of fish. *Public Health Nutr* **15**, 277–284.
42. Duchin F (2005) Sustainable consumption of food: a framework for analyzing scenarios about changes in diets. *J Industrial Ecology* **9**, 99–114.

NS Proceedings of the Nutrition Society