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ECONOMIC IMPACTS OF HEALTH AND FOOD

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Supervisor: Dr. Anil Graves
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ABSTRACT

In the UK, poor diet, associated with high levels of meat, dairy, and sugar consumption, has led to a doubling in the number of people who are overweight or obese in the last twenty five years. The associated social, economic, and environmental costs are high. Tackling diet related health problems is considered to be one of the greatest public health challenges of the 21st century, and the over-consumption of meat and dairy products is linked to high levels of greenhouse gas (GHG) emissions.

The aim of this study was to determine the economic impacts of healthy food habits by reviewing the burden of food related ill health in the UK and the environmental implications of these diets. The first objective was achieved by carrying out an analysis of the costs that the diet-related illnesses pose to the National Health Service (NHS). The analysis showed that £5.6 billion are spent each year on diseases arising as a direct consequence of obesity and overweight, such as cardiovascular diseases, stroke, diabetes and some types of cancer. The second objective focused on the two main contributors to the GHG emissions of the UK food system: food transport and agricultural practices. The transport of fruit and vegetables was found to be responsible for 0.55% of UK total GHG emissions. Although this may appear to be small, it imposes a significant cost on society, estimated to be approximately £178 million when applying the Shadow Price of Carbon (SPC). Regarding agricultural practices, the carbon footprint of UK agriculture is dominated by emissions from the livestock sector. This part of the study used results from a previous study conducted for the Committee on Climate Change, in which three different consumption change scenarios were designed in order to quantify the GHG emissions saved by changing the UK diet. It was found that a 50% reduction in livestock product supply in conjunction with an increase in plant commodities in the diet would result in a 19% reduction in emissions, equal to a saving of £825 million.

Keywords: *Diet, diseases, obesity, cost, GHG emissions, food transport, agriculture, livestock*.

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LIST OF ABBREVIATIONS

UK	United Kingdom
NHS	National Health Service
GHG	Greenhouse Gas
FAO	Food and Agriculture Organisation
FSA	Food Standards Agency
WWF	World Wildlife Fund
WCRF	World Cancer Research Fund
AICR	American Institute for Cancer Research
WHO	World Health Organization
OECD	Organisation for Economic Co-operation and Development
BMI	Body Mass Index
LCA	Life Cycle Assessment
GWP	Global Warming Potential
F&V	Fruit and Vegetables
EU	European Union
HFSS	High in fat, salt or sugar
US	United States
PAF	Population Attributable Fraction
CO_2e	Carbon dioxide equivalent
SPC	Shadow Price of Carbon
SCC	Social Cost of Carbon
FCRN	Food Climate Research Network
Mt	Megatonnes

1 INTRODUCTION

Despite long-established dietary recommendations and public health awareness messages, many amongst the UK population still fail to achieve a healthy balanced diet. An estimated 70,000 premature deaths could be avoided in the United Kingdom if recommended nutritional standards were met (The Cabinet Office, 2008a). This represents more than 10% of current annual mortality, and diet related illness costs the National Health Service (NHS) £10 billion a year (The Cabinet Office, 2008b; Defra, 2012). In addition, public health messages for dietary guidelines have not addressed any of the wider issues of sustainability to date (WWF, 2011) since the notion that personal choice of diet might play a role in environmental sustainability is relatively new (Berners-Lee *et al.*, 2012). Although it is still unknown if it is possible to have a diet that meets dietary requirements for health and is also environmentally, socially and economically sustainable, the Livewell Report published in 2009 by the World Wildlife Fund (WWF) as part of its One Planet Food programme highlighted the links between nutrition and sustainability (WWF, 2011). This indicated that a healthy diet, high in fresh fruit and vegetables and low in meat, dairy and saturated fat could reduce food related greenhouse gas (GHG) emissions by up to 70% by 2050. The UK Climate Change Act of 2008 established a legally binding target for reducing GHG emissions by at least 80% compared to 1990 levels by 2050 (Climate Change Act, 2008). To achieve this target, not only changes in food consumption will be needed, but also in food production.

Changes in food consumption patterns could make a substantial difference to both the environment and public health. For example, it has been estimated that a GHG saving of 22% and 26% could be made by changing the current UK diet to a vegetarian or vegan diet, respectively (Berners-Lee *et al.*, 2012). Even in an omnivorous diet, reducing the consumption of products with the highest embodied GHG emissions, or buying products that have been produced using less GHG-intensive farming practices, would allow the GHG emissions reductions targets to be achieved (Berners-Lee *et al.*, 2012). Current patterns of food consumption are a major modifiable risk factor for several food-related illnesses (Lock *et al.*, 2010). Therefore the shift to a healthier and more sustainable diet would seem to be feasible. A global transition to a low meat and dairy products diet would not only play an essential role in climate change mitigation policies, but also create substantial benefits for human health (Stehfest et al, 2009), since animal foods are linked to several non-communicable diseases (see Figure 2-1 in section 2.1) like obesity, cardiovascular disease or even some kind of cancers (Friel *et al.*, 2009).

From the production perspective, this means that agricultural policies will play an important role in the emission of GHG since agriculture alone accounts for about 10-12% of global GHG emissions (Smith *et al.*, 2007). Agricultural policies could help to contribute to the promotion of healthy diets because they are crucial determinants of what food is produced, sold, and therefore consumed (Lock *et al.*, 2010). A combination of agricultural technology improvements and a reduction in the production of food from animal sources, which is the major contributor to emissions from the agricultural sector (Friel *et al.*, 2009; Stehfest *et al.*, 2009; Eshel and Martin, 2006), could provide an effective strategy for the reduction of emissions (Friel *et al.*, 2009). However, it is worth noting that the impacts of such a change on the livelihoods of livestock farmers is likely to be a significant barrier in implementing low-meat diets (Stehfest *et al.*, 2009).

However, a reduction in meat production (and hence consumption) would involve substantial benefits on public health; therefore, on the whole, it appears that a more holistic assessment of the agricultural and health sectors is needed (WWF, 2011). If sustainability is included as a criterion in nutrient recommendations for health, it is necessary to reconcile environmental, social and economic factors (Lock *et al.*, 2010). This study therefore aims to determine the economic impacts of healthy food habits by reviewing the burden of food related ill health in the UK as well as the environmental implications of the UK diet. To achieve this aim, the following objectives were identified:

1. to analyse the current UK consumers' diet and its link to any diet-related illnesses.
2. to review the possible policy interventions to promote healthy eating habits.
3. to determine the costs that the diet-related illnesses pose to the National Health Service.
4. to determine the GHG emissions derived from agricultural practices, food transportation and food purchasing travels.

2 LITERATURE REVIEW

2.1 UK consumer’s diet habits and diet-related illnesses

The UK diet is too high in saturated fat, sugar and salt and too low in fruit and vegetables according to a recent study of the dietary habits of UK consumers in 2008/09 and 2009/10 carried out by the Department of Health (DH, 2011a). Data from the Food and Agriculture Organisation (FAO) (FAO, 2009) showed that the average energy intake of UK consumers is 3,500 calories per day, which is 1,000 more than recommended by the dietary reference values. These data confirm that the UK population is failing to meet the guidelines for a healthy diet, and as a result, the Food Standards Agency (FSA) in 2007 launched a policy tool to define the Government’s recommendations on healthy diet – the Eatwell plate – (FSA, 2007). In an attempt to integrate the issue of sustainability with the traditional focus on nutrient recommendations, the World Wildlife Fund (WWF) commissioned the *Livewell Report* which endeavoured to develop a nutritionally viable low carbon diet. It is based on the principles of reducing the consumption of meat and processed food as they are the greatest sources of saturated fat, sugar and salt, reducing the wastage of food, and increasing the consumption of certified food, fruit, and vegetables (WWF, 2011). Linked in with this last principle, Defra launched in 2003 the ‘5 A Day’ campaign as a major part of the Government’s framework for encouraging consumers to eat at least 5 portions of fruit and vegetables a day in order to help prevent health problems (Defra, 2003a).

The association between dietary patterns and health has been broadly studied through the literature over the years. Promoting healthy eating habits is a way to prevent the onset of diet-related illnesses (Schwartz *et al.*, 2011). The UK’s unhealthy diet pattern has in recent years led to an increase in the occurrence of some diseases (see Figure 2-1) such as obesity, type 2 diabetes, heart disease and some kinds of cancer (WWF, 2011).

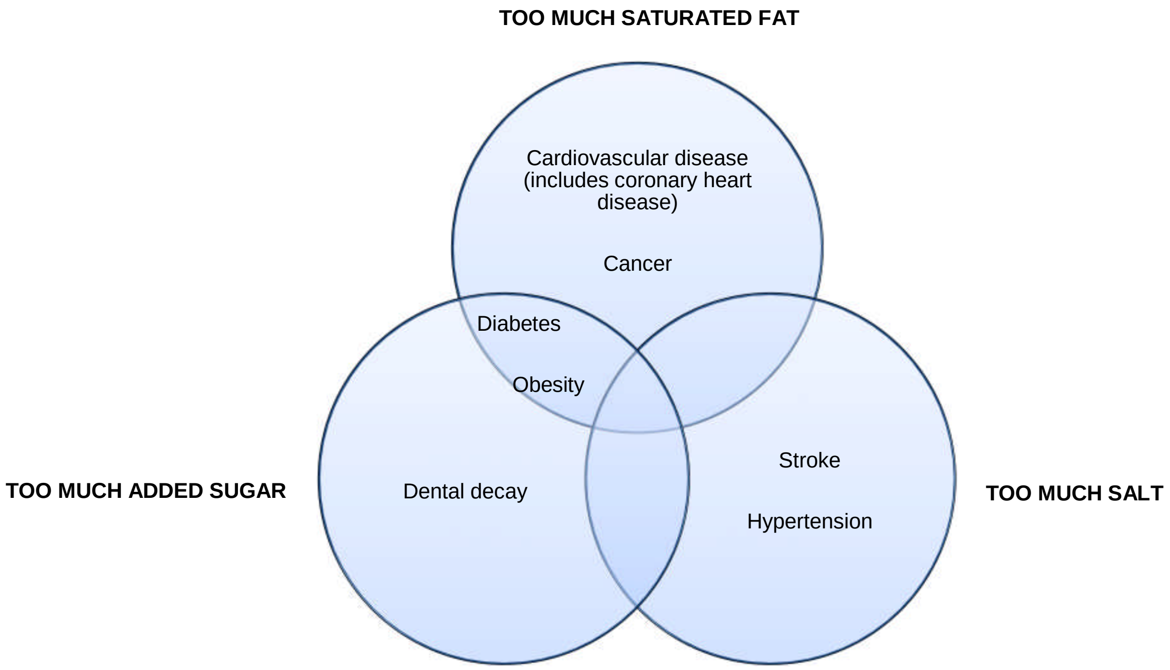

Figure 2-1: Diet-related illnesses. (Source: based on The Cabinet Office (2008b) p. 93).

A particular group of foodstuffs, those obtained from animals such as meat and dairy products, are major sources of saturated fats in the human diet, have high calorie contents and this, added to the meat-related carcinogens, lead to several non-communicable diseases (Friel *et al.*, 2009) as shown schematically in Figure 2-2.

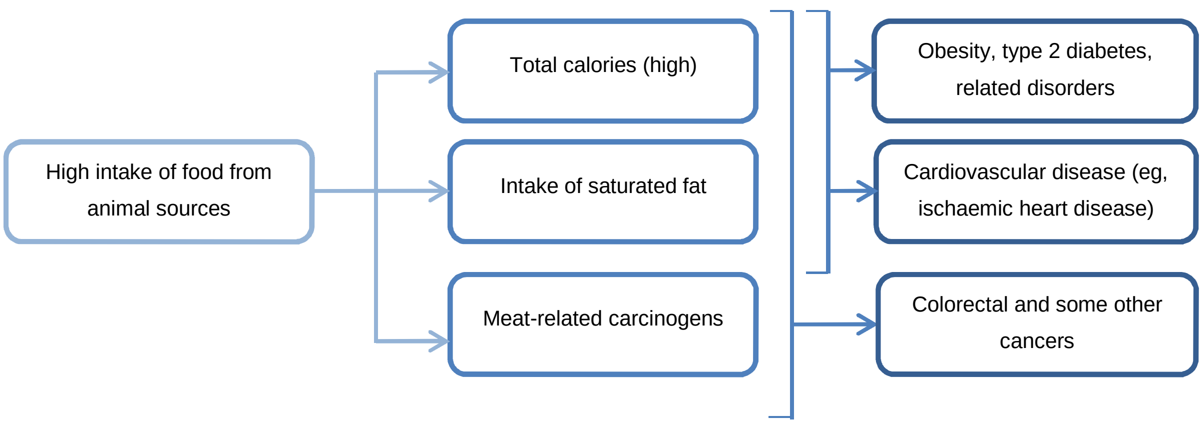

Figure 2-2: **Health outcomes from high intake of food from animal sources. (Source: adapted from Friel *et al.* (2009) p. 2018).**

There is solid evidence that food obtained from animal sources have adverse effects on public health (Friel *et al.*, 2009; Stehfest *et al.*, 2009, Scarborough *et al.*, 2012a). According to the World Cancer Research Fund (WCRF) and American Institute for Cancer Research (AICR), the consumption of beef and pork meat increases the risk of intestinal cancer (WCRF and AICR, 2007), and a reduction in the consumption of meat high in saturated fat can lower the risk of coronary heart disease (Li *et al.*, 2005). However, the incidence of these diseases is also increased by a diet low in fruit and vegetables (Gillman *et al.*, 1995; Joshipura *et al.*, 1999; Hu *et al.*, 2000; Joshipura *et al.*, 2001), an it has been proven that these provide protection against cardiovascular diseases and some cancers (WCRF and AICR, 2007). In fact, according to Lock *et al.* (2005) and the World Health Organization Report (WHO, 2002), the total worldwide mortality currently attributable to inadequate consumption of fruit and vegetables is estimated to be up to 2.7 million deaths per year, which represents 4.4% of the overall burden of disease in Europe (WHO, 2002) and 1.8% worldwide (Ezzati *et al.*, 2003). The promotion of fruit and vegetable consumption needs an ‘intersectoral approach’ focused both on the supply of and the demand for these products. This then implicates stakeholders in both the public and private sectors, as well as international bodies, civil society and non-governmental organisations (Pomerleau *et al.*, 2006).

With respect to the magnitude of this issue in the UK, according to a report published by the Cabinet Office in 2008, around 70,000 premature deaths could be avoided each year in the UK if the nutritional recommendations on fruit and vegetable consumption and saturated fat, sugar and salt intake were met. More specifically, 42,200 premature deaths could be avoided each year if the UK population met the ‘5 A Day’ target and 20,200 deaths could be avoided by reducing daily salt intake from an average of 9g to 6g. In addition, reducing saturated fat and added sugar intake to recommended levels would save another 7,000 lives, making a total of 69,400, equivalent to about the 10% of the overall annual premature death rate in the UK (The Cabinet Office, 2008b).

The economic implication of this is that food related diseases cost the NHS about £10 billion annually (The Cabinet Office, 2008b; Defra, 2012), which represents twice the amount attributable to traffic accidents and more than twice that attributable to smoking (Rayner and Scarborough, 2005). The disease that represents the highest percentage in this figure is obesity, as 23% of adults and about 10% of children are already classed as obese (The Cabinet Office, 2008a; The Scottish Government, 2012).

This section describes the relationship between diet and diseases in particular focussing on the link between diet and obesity.

2.1.1 Diet and the burden of disease

2.1.1.1 Low consumption of fruit and vegetables

There is solid evidence that high fruit and vegetable consumption can significantly reduce the risk of certain illnesses like heart disease and stroke and lower total mortality (Gillman *et al.*, 1995; Joshipura *et al.*, 1999; Hu *et al.*, 2000; Joshipura *et al.*, 2001). It has been estimated that eating at least 5 varied portions of fruit and vegetables a day could lead to reductions of up to 20% in overall deaths from chronic diseases such as the mentioned above and cancer (DH, 2000). Joshipura *et al.*, (2001) found that each increase of one portion of fruit or vegetables a day reduced the risk of coronary heart disease by 4% and the risk of stroke by 6%.

The protective role of the consumption of fruit and vegetables against cancer is more controversial (Parkin and Boyd, 2011a). Although the evidence base is substantial, findings are inconsistent, and the WCRF and AICR panel concluded in its report in 2007 that non-starchy vegetables, fruits and other foods containing dietary fibre *may* protect against a range of cancers such as mouth, stomach, lung, colon or rectum cancers (WCRF and AICR, 2007). An association of diet with cancers of the bladder, pharinx and larynx has been examined (Lock *et al.*, 2005). The data show that the fraction of cancer attributable to low consumption of fruit and vegetables in Europe is between 13 and 24% for stomach and oesophageal cancers, 8 and 16% for lung cancer and

1 and 3% for colorectal cancer (Lock *et al.*, 2005). In the UK, Parkin and Boyd (2011a) using data from the WCRF, estimated the overall attributable fraction of all cancers in the UK during 2010 due to low consumption of fruit and vegetables as 7.1%, with lung cancer being the major contributor representing 60% of these cases (WCRF and AICR, 2009; Parkin and Boyd, 2011a).

2.1.1.2 Meat consumption

The association between consumption of red and processed meat and the risk of several types of cancer is well established, particularly for colorectal cancer, which is the only one that the WCRF and AICR 2007 report considered to be a 'convincing' cause of cancer. The term "processed meat" refers to any meat that is prepared by methods like marinating, smoking or salting, or preserved by the addition of preservatives like nitrites and nitrates. Some examples are ham, bacon, sausages and tinned meat, and although there are no dietary guidelines for recommended levels of consumption, it is assumed that 'less is better' (Parkin, 2011). In fact, several studies have shown significant reductions in cancer risk among consumers who avoid meat, and a 40% reduction has been shown in vegetarians (Chang-Claude *et al.*, 1992; Chang-Claude and Frentzel-Beyme, 1993; Thorogood *et al.*, 1994).

According to the WCRF and AICR 2007 report and the study undertaken by Parkin (2011), the percentage of colorectal cancer diagnosed in 2010 in the UK attributable to consumption of red meat was 21.1%, which was 2.7% of the total burden of cancer in the UK for the same year.

A number of hypotheses have been advanced to explain the connection between meat consumption and cancer risk, such as: (1) the carcinogenic compounds like heterocyclic amines and polycyclic aromatic hydrocarbons formed during the processing or cooking of meat (Norat and Riboli, 2001; Cross and Sinha, 2004); (2) the carcinogenic compounds that can be produced from the nitrites and nitrates added to meat as preservatives, coloring, or flavoring agents (The Cancer Project, 2012); (3) the increase in hormone production arising from the high fat content of meat, which is believed to increase the risk of hormone-related cancers such as breast and prostate cancer (Armstrong and Doll, 1975; Carroll and Braden, 1984; Rose *et al.*, 1986), and; (4) the growth of bacteria present in meat that cause the proliferation of carcinogenic secondary bile acids in the intestine (The Cancer Project, 2012).

Meat consumption has been associated with other types of cancer in epidemiological literature, such as cancer of the oesophagus, lung, stomach, breast, prostate, kidney and pancreas, although the strength of these associations is not consistent because evidence is more 'limited' than for colorectal cancer (WCRF and AICR, 2007).

Other health problems associated with the consumption of meat in the UK found in the literature are a higher risk of developing diseases such as type 2 diabetes (Fretts *et al.*, 2012; Woudenbergh *et al.*, 2012), stroke (Larsson *et al.*, 2011) and cardiovascular disease (Heidemann *et al.*, 2008; Friel *et al.*, 2009).

2.1.2 Diet and obesity

According to the World Health Organization (WHO, 2002) 7.8% of the overall burden of disease in Europe can be attributed to obesity[1] and overweight[2]. The Organisation for Economic Co-operation and Development (OECD) called for strong action against obesity in 2010 given the fact that at least one in two people is now overweight or obese in over half of OECD countries (OECD, 2012). In the UK, nearly 25% of adults and about 10% of children are already classed as obese (The Cabinet Office, 2008a). This involves a significant healthcare cost associated with the treatment of obesity and the wide range of chronic diseases arising as a direct consequence of obesity and overweight (McCormick and Stone, 2007).

An obese person incurs 25% higher health expenditures than a person of normal weight in any given year (OECD, 2012). The total economic cost for

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[1] The word 'obesity' is taken to refer either generally to a raised Body Mass Index (BMI) or specifically to a level of BMI greater than or equal to 30.
[2] The word 'overweight' is taken to refer a level of BMI greater than 25 and lower than 30.

obesity in England has been estimated to be £3.3 to £3.7 billion per year, a cost that is doubled when the economic cost attributable to overweight is included (HCHC, 2004). This equated to 2.3–2.6% of total NHS expenditure in 2001/02. The vast majority of this sum is attributable to treating the consequences of obesity such as cardiovascular disease, type 2 diabetes, stroke, or various cancers, rather than treating obesity itself (McCormick and Stone, 2007). However, it is noteworthy that these costs not only include treatment of obesity, overweight or the diseases related with them, also known as direct costs, but also include indirect costs arising from the impact of obesity on the wider economy, such as loss of productivity due to absence from work caused by sickness, and adverse social consequences through discrimination or social exclusion. According to a recent Foresight report, obesity already costs the wider economy in the UK £16 billion per year. The report predicts that costs to the NHS derived from obesity and diet-related illnesses will exceed £10 billion each year by 2050, whilst the wider costs to society is estimated to rise to more than £50 billion (Foresight, 2007).

2.2 Environmental impacts of food

2.2.1 Local food

Local food refers to an idea that has no firm definition in terms of the geographic distance between production and consumption (Pearson *et al.*, 2011; Martinez *et al.*, 2010; Defra, 2003b). The most broadly accepted definition appears to be provided by Pearson *et al.* (2011) who defined local food as food which is both produced and sold within the same area.

Interest in local food arose in the UK during the late 1980s and early 1990s, and has grown noticeably since then motivated by policy support because of its potential to benefit both rural development and farmer incomes (Kirwan and Maye, 2012). A report from the Policy Commission on the Future of Farming and Food (Defra, 2002) encouraged local producers to build on the direct benefits that consumers attribute to locally produced food, i.e. quality, freshness and authenticity (Brown and Geldard, 2008). The growing interest of consumers in what they eat, where the food comes from, and how it is produced, added to the environmental benefits from reducing the transportation distance and the fact that benefits are retained locally (Pearson *et al.*, 2011) has boosted the achievement of sustainable food production, distribution and consumption in terms of social, economic and environmental dimensions (Jarosz, 2008; Brown and Geldard, 2008; Pearson *et al.*, 2011).

2.2.2 Environmental impacts and the issue of 'Food Miles'

According to the Cabinet Office (2008a) around 18% of UK GHG emissions are related to food production and consumption largely because of the movement of food between nations. The concept 'food miles' is based on the idea that the longer the distance that the food has to be transported from the farm to the consumer's plate, the higher will be its negative environmental impact (Kemp *et al.*, 2010). In recent years, the food miles concept has gained importance in the UK due to the fact that around 90% of the fruit and 40% of the vegetables consumed in the country are grown overseas and imported from distant locations on heavy good vehicles, ships and planes (Garnett, 2006). Indeed, fruit and vegetables are the food group for which the UK has the largest trade deficit, since the value of imports in 2010 was £7.6 billion against the value of exports which was £0.8 billion, resulting in a trade gap of £6.8 billion (Food Statistics Pocketbook, 2011).

The UK Farmers Weekly claimed in a campaign in 2006 that "local food is miles better" (FWI, 2006). The tendency to see local food as a solution to the problem of food miles has arisen because localisation is seen to decrease the distance food travels (Kirwan and Maye, 2012). However, according to Coley *et al.* (2009), the ideas behind localism in the food chain and reduced food miles need to be reconsidered using techniques such as Life Cycle Assessment (LCA) since these provide a more holistic view of the food chain, incorporating the environmental impacts associated with food products throughout all stages of their life cycle (Lee *et al.*, 1995).

Kulak (2010) conducted a LCA of the potential savings of food related GHG emissions that could be achieved with the establishment of an urban community farm in the London Borough of Sutton for the local production of fruit and vegetables. He compared the emissions derived from the delivery of these products from the community farm with the emissions related to their delivery from conventional supplies. The analysis demonstrated that the imported fruit and vegetables (e.g. apples, spinach, pumpkin, green beans, maize, courgettes) had a Global Warming Potential[3] (GWP) more than four times greater than the same products that were locally produced. However, the magnitude of these differences was largely due to GHG emissions in the production and refrigeration of products in the conventional supply system, rather than their transport.

2.3 Policy interventions to promote healthy eating habits

Food related ill health has been given little attention by health and food policy makers until recently (Rayner and Scarborough, 2005), and this is the reason why the EATWELL Project was funded in 2009 by the Seventh Framework Programme (FP7). Its main objective was to develop appropriate policy interventions that will encourage and evaluate healthy eating habits across Europe (Traill *et al.*, 2012; EATWELL, 2012). These interventions can be classified into two categories, namely: (1) information/regulation measures, and (2) fiscal measures (Traill *et al.*, 2010; Capacci *et al.*, 2012). Below a review of the effectiveness of some of the policy actions implemented to date in different countries is presented.

2.3.1 Information/regulation measures

These measures aim to enable consumers to make informed choices through the provision of information or education. Commonly used policy interventions are public information campaigns, nutrition labelling, advertisement controls and nutritional education.

[3] Global Warming Potential for a particular greenhouse gas is the ratio of heat trapped by one unit mass of the greenhouse gas to that of one unit mass of CO_2 over a specified time period (usually 100 years) (EPA, 2011).

2.3.1.1 Public information campaigns

These try to improve knowledge on healthy diet habits through the media and other social marketing tools. This is the most common type of policy intervention to promote healthy eating, and one of the most widespread actions is the campaign that aims to increase fruit and vegetable consumption, generally based on the "5 portions a day" message. The UK launched the '5 A Day' campaign in 2003 in an effort to encourage consumers to increase their fruit and vegetable intake to at least five portions a day. Average daily consumption among adults in the UK is around 3.7 portions per day, with only 13% of men and 15% of women meeting the recommended intake (Collins *et al.*, 2003). Such public information campaigns appear to be an effective means of increasing the consumption of healthy food as an analysis of the campaigns in the UK and Italy demonstrate (Table 2-1).

Table 2-1: Evidence of the impact of public information campaigns. (Source: adapted from Capacci et al., (2012)).

Public Information Campaign	Impact evaluated	Effectiveness
'5 A Day', UK	Impact on consumption and awareness (Capacci and Mazzocchi, 2011)	The average impact of the campaign can be estimated at about +0.3 portions of fruit and vegetables per person per day. Differentiated impact by income group, ranging from 0.2 to 0.7 portions. They highlight a positive impact on awareness, despite the small increase in actual F&V consumption.
	Impact on awareness (FSA Consumer Attitudes Survey)	The survey shows an increase in awareness of the 5 A Day message, from 52% in 2002 to 59% in 2003.
	Impact on consumption (Ipsos-UK's Capibus, on behalf of COI Communications for the Department of Health, 2004; cited in Capacci *et al.*, 2012)	37% of respondents claim to have eaten more fruit and vegetables over the past 12 months, with that number rising to 40% in the lowest socioeconomic groups, compared to 32% in the highest.
'I 5 colori del benessere', Italy	Impact on attitudes/knowledge (Della Casa and Daltri, 2007; cited in Capacci *et al.*, 2012)	56% of respondents were willing to increase their consumption of F&V.
'Eat Well Live Healthy', Italy	Impact on self-assessed behaviour (Italian Ministry of Health, 2004).	37.8% of surveyed declared having improved their dietary habits as a consequence of the campaign.

2.3.1.2 Nutrition labelling

Nutrition labels enable consumers to make healthier choices about food. The EU-funded Food Labelling to Advance Better Education for Life (FLABEL) project aimed to study the impact of food labelling on consumers' dietary choices in Europe (FLABEL, 2012). Several assessments of the impact of labelling on food intake do not show conclusive results in terms of healthier purchasing choices (Steenhuis *et al.*, 2004; Variyam, 2008). However, a study on American consumers concluded that "food label use decreases individuals' average daily intakes of calories from total fat and saturated fat, cholesterol, and sodium by 6.90%, 2.10%, 67.60 milligrams, and 29.58 milligrams, respectively". It also concluded that label use increased average daily fibre intake by 7.51 grams (Kim *et al.*, 2010).

2.3.1.3 Advertisement controls

Food-advertising regulations are often used to protect children from exposure to advertisements of products that are high in fat, salt or sugar (HFSS). Data from the UK and France (Table 2-2) suggested that such controls are effective in reducing exposure to advertising, and in the case of France, effective in reducing the purchase of unhealthy food.

Table 2-2: Evidence of the impact of advertising regulations. (Source: adapted from Capacci *et al.*, (2012)).

Advertising Regulation	Impact evaluated	Effectiveness
HFSS advertising restriction, UK	Change in exposure to the messages (OFCOM, 2010)	Children saw around 37% less HFSS advertising, more specifically: - Younger children (4-9 year old) saw 52% less advertisement on unhealthy food. - Older children (10–15 year old) saw 22% less advertisement on unhealthy food.
Food advertising regulation, France	Impact on self-reported behaviours (Ministère de la Santé, de la Jeunesse et des Sports, 2008)	21% of surveyed individuals above age 15 reported having changed their eating habits after the enactment of the measure. 17% of surveyed individuals above age 15 reported having changed their food-purchasing habits after the enactment of the measure.

2.3.1.4 Nutritional education

The vast majority of these measures are targeted at schoolchildren, aiming to increase their awareness of the importance of having a healthy diet. Such nutritional education programmes included the introduction of fruit and healthy mid-morning snacks in schools, and training for families through meetings and educational booklets.

A further measure affecting food and nutrient availability that could be included in the "nutritional education" category is the regulation of nutritional composition of meals in public-sector establishments such as schools, workplaces or hospitals. By regulating the foodstuffs and drinks sold at vending machines, and the nutritional content of meals, a positive effect on behaviour has been observed (Table 2-3). However, the changes in behaviour reported are recorded at the place of intervention and therefore do not take into consideration any compensating behaviour outside the school (Capacci *et al.*, 2012).

Table 2-3: Evidence of the impact of nutritional education programmes. (Source: adapted from Capacci *et al.*, (2012)).

Nutritional Education Campaign	Impact evaluated	Effectiveness
Nutritional education programme for school children, Italy	Impact on consumption (Dulcetti *et al.*, 1997)	76% of children not involved in the project reported snack consumption (not fruit) at school, whereas the proportion for children involved in the project was 16%. Increase of 2.9% in the proportion of children who had healthy snacks 1-2 times a day.
'Frutta snack', Italy	Impact on attitudes (Zappalà, 2008)	67% of children involved in the project reported an improvement in their nutritional knowledge about the importance of fruit and vegetables.
Introduction of healthy menus in schools, Scotland	Impact on consumption (Eagle, 2009)	Healthy food intake among students increased from 39% to 74%.

2.3.2 Fiscal measures

These measures include taxes on unhealthy foods or nutrients and subsidies on healthy foods, sometimes referred to as ‘fat taxes’ and ‘thin subsidies’ (Traill *et al.*, 2010; Capacci *et al.*, 2012). The intention of these policy interventions is both to encourage healthier eating and, in the case of the taxes, to charge people for the social costs they cause, such as healthcare costs and economic productivity costs (Traill *et al.*, 2010). Several countries such as Denmark, Hungary, Finland, France or the United States have already introduced taxes on unhealthy food and beverages as part of their efforts to counter obesity. In the United States, special taxes on soft drinks, confectionary and snacks generate about $1 billion per year. This aims to counter the impacts of poor diet that, together with physical inactivity, causes about 310,000 - 580,000 premature deaths annually as a result of diet-related diseases, imposing an annual cost of around $71 billion (US Department of Agriculture, cited in Jacobson and Brownell, 2000).

The UK Government is considering the implementation of a combination of subsidies on fruit and vegetables and taxes on foods of low nutritional value (i.e. snack foods and soft drinks). The health effects of these interventions would be a delay in the onset of obesity rather than a reduction in mortality, and the expected savings in health expenditure would be counterbalanced by the additional need for medical care due to the enhanced survival rates resulting from the implementation of these measures. According to Powell and Chaloupka, (2009) the low level of these taxes together with a rather inelastic demand makes them ineffective when it comes to addressing behaviour, and there is limited existing evidence suggesting that small taxes or subsidies can produce significant changes in body mass index (BMI) or obesity prevalence.

3 METHODOLOGY

The method for this research involved three major stages. Stage 1 used the literature review presented above to identify the main health and environmental impacts associated with poor diet. Stage 2 involved collecting data on the economic costs associated with the impacts identified in the literature. All data were taken or adjusted for 2010, the baseline year for the study. In Stage 3, a simple computer-based spreadsheet model was created in a Microsoft Excel platform to combine the data and calculate the overall economic impacts of poor diet on health and the environment in the UK under a range of different scenarios. The model consisted in several worksheets within a single Excel workbook.

3.1 Literature review

In order to complete the brief defined by Bioregional, a review of literature was conducted to identify the main health and environmental impacts associated with poor diet and the potential benefits associated with improving diet (Section 2.1 – 2.3). A review of literature was also used to assess the benefits and efficacy of policy interventions implemented so far across Europe (2.3).

3.2 Data collection

3.2.1 Poor diet, obesity and the cost of disease

Data for obesity and overweight prevalence in the UK were gathered from government websites for each of the home nations, and contrasted with the National Obesity Observatory publications. With regard to the burden of disease attributable to high BMI, a detailed review of the literature was conducted, in order to select the diseases whose incidence has been proven to be higher in obese people. A total of seven diseases were chosen for the study, listed below in descending order of linkage with obesity/overweight.

- Diabetes
- Osteoarthritis
- Corpus uteri cancer
- Cardiovascular disease
- Stroke
- Colorectal cancer
- Breast cancer

For each of these diseases, and using the Gross Domestic Product deflators provided by HM Treasury, the original economic costs of poor diet and overweight/obesity, estimated for 2002 by Scarborough *et al.* (2011), were updated for 2010 prices, the baseline year for this study.

For the calculation of the expenditure per patient on each BMI-related disease, the following data were calculated:

- Number of cases diagnosed in the UK in 2010.
- Number of deaths in the UK in 2010 using data from ONS (2011), NISRA (2011) and General Register Office for Scotland (2011).
- Number of cases currently in the UK, i.e. number of people currently living in the UK who have been diagnosed with the disease.
- Population Attributable Fraction (PAF) for each disease, i.e. the fraction of cases diagnosed in 2010 that are attributable to high BMI.

In addition, a review was conducted in order to find out the possible deaths that could be avoided if the UK guidelines or the '5 A Day' target were met (See sections 4.2.3 and 4.2.3.1).

The health benefits of reducing the consumption of meat were also analysed, focussing on the potential reduction in the number of cases diagnosed for colorectal cancer and ischaemic heart disease per year that could be achieved under a hypothetical scenario of 50% reduction in livestock products consumption.

Finally, an analysis on the possible impacts that a reduction in the sugar content as described in Scenario 1, for public health and obesity was undertaken.

3.3 Model development: Poor diet and sustainability

The approach given to this part of the study was to undertake an analysis of the contribution to UK GHG emissions of each sector in the food industry. Data for this purpose were obtained from the report for the FCRN carried out by Garnett (2007). A simple framework was developed in order to quantify the tonnes of CO_2 equivalent (CO_2e[4]) released by the activities within each selected sector, taking the value for the total UK GHG emissions from DECC (2012), and considering not only the CO_2 emissions, but also the Kyoto GHG basket.

In this model, the economic cost of the emissions associated with each sector was calculated using the Shadow Price of Carbon (SPC[5]), whose value was taken from DECC (2011) for the non-traded sector since emissions from agriculture and transport are not covered by the EU Emission Trading Scheme. The value taken was 55£/tC, corresponding to the value of carbon in 2010 (See Appendix A for a summary of all carbon values over the 2008-2050 period).

Research indicates that the sectors contributing most to the UK carbon footprint within the food chain are transport and agriculture. The costs for these were calculated in two different spreadsheets, as described below.

3.3.1 Food transport

A breakdown of the emissions from each means of transport in the food chain was made with data from Defra (2007) assuming that these data would be similar for 2010. The calculations were done only for the fruit and vegetable

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[4] Carbon dioxide equivalent is a universal unit of measurement that allows the global warming potential of different GHGs to be compared (Defra, 2011a).

[5] Shadow Price of Carbon: The government has moved away from using a Social Cost of Carbon (SCC) to the Shadow Price of Carbon. The SCC is an economic tool which estimates the monetary costs over the next 100 years of releasing one additional tonne of carbon to the atmosphere today (Defra, 2005). The SPC is the value that will be placed by government on carbon impacts when evaluating policy options (DECC, 2008). The SPC is calculated for the optimal level of emissions given the objective function and the various constraints whereas the SCC can be calculated away from the optimum (Defra, 2007).

sector, since this is the major contributor to the overseas emissions because of the UK's low self-sufficiency, also calculated in this study with data from Defra (2011) for the tonnes of home production marketed, imports, exports and consumption (See Appendix B).

Consequently, the economic cost which the fruit and vegetables sector incurs due to the emissions derived from transportation has been calculated following the same steps as previously detailed, applying the SPC for translating into money these environmental impacts.

3.3.2 Agricultural practices

Since livestock rearing contribute most to GHG emissions, this study focused on the emissions from livestock production.

As a basis for the calculations, the results obtained in a study conducted at Cranfield University for the Committee on Climate Change (Audsley *et al.,* 2009b) were used. In this report, three different scenarios were designed in order to assess the environmental impacts that a change in the UK diet would have. The economic costs of livestock production in these three scenarios due to the emissions released were also calculated using the SPC.

4 RESULTS AND DISCUSSION

In this section, the results and discussion are presented together to facilitate comprehension of the analysis developed during this research. It should also be noted that some of the data here are from the literature, as this was a requirement of the brief provided by BioRegional. As a way of differentiating these results from the data and analysis developed independently by the author, the latter appear in the tables on a shaded background.

4.1 Poor diet, obesity and the cost of disease

The results show that 60.8% of adults in the UK have a BMI above 25, with about 23% of people being obese (The Scottish Government, 2012). Table 4-1 shows the obesity and overweight prevalence in the different constituent countries of the UK. Scotland is the most obese country in the UK.

Table 4-1: Obesity and overweight prevalence in the UK

	Obesity prevalence 2010 (%)		Overweight prevalence 2010 (%)	
	Adults	**Children**	**Adults**	**Children**
England	26.1[1]	14.4[3]	35.2[3]	13.9[3]
Wales	22[1]	19[4]	36[8]	17[4]
Scotland	28.2[1]	14.2[5]	36.8[9]	15.6[9]
Northern Ireland	23[1]	8[6]	36[6]	26.5[11]
UK	23[2]	16[7]	37.8[10]	15.1[10]

1 National Obesity Observatory (2012) **2** The Scottish Government (2012) **3** DH (2011b) **4** National Assembly for Wales (2012) **5** The Scottish Government (2011a) **6** Northern Ireland Executive (2011) **7** NHS (2012) **8** NHS Wales (2010) **9** The Scottish Government (2011b) **10** BBC Health (2011) **11** CSP (2009).

These different levels of obesity correspond to different levels of diseases in the different UK nations, since obesity is linked pathologically to a number of serious health conditions, (Kopelman, 2007; Lang and Rayner, 2007) which include coronary heart disease, hypertension and stroke, certain types of cancer and type 2 diabetes (WHO, 2000). Thus Scotland, Wales and Northern Ireland were found to have higher rates of mortality from cardiovascular disease and cancer than England as they have a poorer diet based on a higher saturated fat and salt consumption and lower fruit and vegetable intake

(Scarborough *et al.*, 2011). Table 4-2 shows the likelihood of developing certain chronic diseases.

Table 4-2: Burden of disease attributable to high BMI

Disease	% attributable to high BMI	Source
Cardiovascular disease	23%	WHO (2012)
Osteoarthritis	27% of cases of hip arthroplasty 69% of cases of knee arthroplasty	Grazio and Balen (2009)
Diabetes	80–85% of the overall risk of developing type 2 diabetes *(Type 2 diabetes accounts for around 90% of people with diabetes).* 77%	Diabetes UK (2011a) Kelly *et al.* (2009)
Stroke	14%	Kelly *et al.* (2009)
Corpus uteri cancer	33.7%	Parkin and Boyd (2011b)
Colorectal cancer	13%	Parkin and Boyd (2011b)
Breast cancer	9%	Parkin and Boyd (2011b)

Obesity related illnesses affect people's quality of life and also create serious financial and social burdens (Foresight, 2007). An exhaustive analysis of the economic burden of ill health in the UK showed that the largest contributors to NHS expenditure were poor diet, overweight and obesity (Scarborough *et al.*, 2011) (Tables 4-3 and 4-4).

Table 4-3: Original and updated economic costs of overweight/obesity to the NHS. (Source: Scarborough *et al.*, (2011)).

	UK 2006-07		UK 2010-11[1]
	Million £/year	**% of total**	**Million £/year**
Cardiovascular disease	2,922	56.78	3,211.5
Osteoarthritis	853	16.58	937.5
Diabetes	835	16.23	917.7
Stroke	332	6.45	364.9
Corpus uteri cancer	80	1.55	87.9
Colorectal cancer	65	1.26	71.4
Breast cancer	59	1.15	64.8
Total	5,146	100.00	5,655.9

1 Updated costs using the Gross Domestic Product deflators provided by HM Treasury (2012). (See Appendix C).

Table 4-4: Original and updated economic costs of poor diet to the NHS. (Source: Scarborough *et al.*, (2011)).

	UK 2006-07		UK 2010-11[1]
	Million £/year	**% of total**	**Million £/year**
Cardiovascular disease	2,468	42.60	2,712.53
Diabetes	751	12.96	825.41
Cancer	1,663	28.71	1,827.77
Dental caries	912	15.74	1,002.36
Total	5,793	100.00	6,366.97

1 Updated costs using the Gross Domestic Product deflators provided by HM Treasury (2012). (See Appendix C).

Whilst studies such as the Government's Foresight programme (Foresight, 2007) have estimated both the direct and indirect costs of overweight and obesity related diseases, the data used for this study focussed on the expenditure per obese patient for the most significant BMI-related diseases in the UK. The results which are derived from many different sources are shown in Table 4-5.

Table 4-5: Number of new cases per year, total current cases, deaths per year and expenditure per patient and year in the UK for several BMI-related diseases.

	Ischaemic heart disease	Osteoarthritis	Diabetes	Stroke	Corpus uteri cancer	Colorectal cancer	Breast cancer
No. cases diagnosed in 2010	275,000[1]	175,000[7]	130,000[12]	150,000[14]	8,195[17]	39,914[17]	48,385[17]
Of which, attributable to high BMI	63,250[2]	85,050[8]	99,450[13]	21,000[15]	2,762[17]	5,189[17]	4,355[17]
No. deaths due to the disease 2010	80,534[3]	No data available	6,170[3]	49,374[3]	1,912[3]	16,039[3]	11,575[3]
No. cases currently in UK	2,600,000[4]	8,500,000[9]	2,912,657[12]	1,200,000[16]	38,667[18]	143,558[20]	550,000[22]
Of which, attributable to high BMI	598,000[2]	4,131,000[10]	2,228,183[13]	168,000[15]	13,031[17]	18,663[17]	49,500[17]
Expenditure on the disease related to BMI (million £/year)	3,211.5[5]	937.5[5]	917.7[5]	364.9[5]	87.9[5]	71.4[5]	64.8[5]
Expenditure per patient (£/year)	5,370[6]	5,357[11]	412[6]	2,172[6]	15,418[19] 3,855[19] 3,885[19]	8,745[21] 2,186[21] 2,186[21]	2,094.5[23] 523.6[23]

[1] BBC Health (2012) [2] WHO (2012) [3] ONS (2011), NISRA (2011) and General Register Office for Scotland (2011) [4] NHS choices (2012) [5] Inflated costs based on Scarborough *et al.* (2011) [6] Expenditure on the disease related to BMI / No. cases currently in the UK attributable to high BMI [7] Estimated number of knee and hip procedures in England, Wales and Scotland (National Joint Registry, 2011 and NHS National Services Scotland, 2010) [8] Grazio and Balen (2009) [9] Arthtritis care (2012) [10] Estimated based on data from Grazio and Balen (2009) that affirm that 27% of cases of hip arthroplasty and 69% knee arthroplasty may be attributed to obesity. [11] Expenditure on the disease related to BMI / No. hip and knee procedures in 2010 [12] Diabetes UK (2011b) [13] Diabetes UK (2011a) [14] Patient.co.uk (2012) [15] Kelly *et al.* (2009) [16] British Heart Foundation (2012)[17] Parkin and Boyd (2011a) [18] Prevalence after 10 years after diagnosis (Cancer Research UK, 2010) [19] It is considered that during the first year after diagnosis, the treatment for each person is 2 times more expensive than during the following 5 years, and 4 times more expensive than more than 5 years after diagnosis. It is assumed that 25% of the 13,031 people were diagnosed in 2010, 50% within 2 and 5 years ago, and 25% more than 5 years ago [20] Prevalence after 10 years after diagnosis (Cancer Research UK, 2012) [21] It is considered that during the first year after diagnosis, the treatment for each person is 2 times more expensive than during the following 5 years, and 4 times more expensive than more than 5 years after diagnosis. It is assumed that 25% of the 18,663 people were diagnosed in 2010, 50% within 2 and 5 years ago, and 25% more than 5 years ago [22] Breast Cancer Care (2012) [23] During the first 5 years after diagnosis, the treatment for each person is 4 times more expensive than after. It is assumed that 50% of the 49,500 people were diagnosed within the last 5 years and 50% more than 5 years ago, since the number of cases diagnosed per year attributable to high BMI is equivalent to about one tenth of the total number of BMI-related cases currently in the UK.

4.2 Diet and sustainability

The consumption and production of food contributes to around 19% of the UK's GHG emissions. According to a report by Garnett (2008) for the Food Climate Research Network (FCRN), agriculture accounts for around 40% of food's total GHG emissions, with the remaining 60% evenly distributed among the manufacturing, retailing, transport, catering and domestic stages (Figure 4-1).

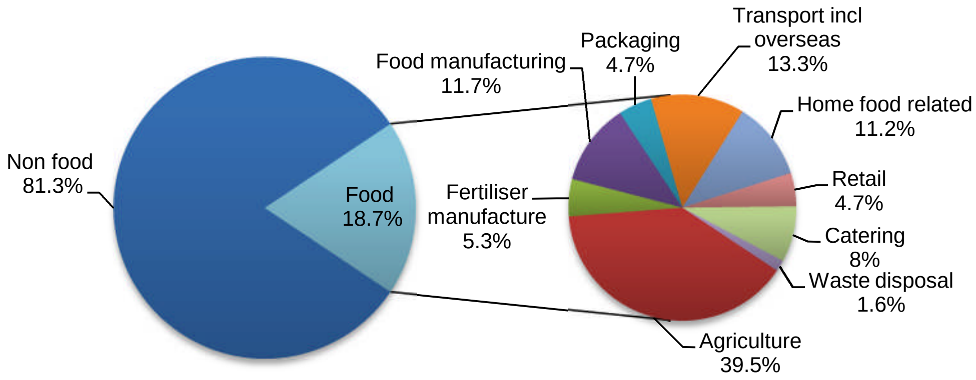

Figure 4-1: Breakdown of food chain GHG emissions in the UK. (Source: Adapted from Garnett (2007)).

Emissions of GHG in the UK food chain are estimated to be 590.4 Mt CO_2e (see in Appendix A figure for year 2010; DECC, 2012), with the two main contributing sectors in agriculture, largely due to meat and dairy products, and transport, largely due to the rapid increase of air freight transport for imported products like fruit and vegetables (Garnett, 2007). The economic cost of this was calculated using the SPC value for 2010 taken from DECC (2011) (55£/tC) (See Appendix A). Table 4-6 summarizes the emissions derived from each sector within the food industry and the associated economic cost of those emissions.

Table 4-6: UK GHG emissions and economic costs and breakdown for each sector within the food industry.

	% UK GHG emissions	Mt CO_2e/year	Economic cost (million £/year)
Non food	81.3	480.00	26,399.74
Food	18.7	110.40	6,072.26
Agriculture	***7.4***	***43.69***	***2,402.93***
Fertiliser manufacture	*1.0*	*5.90*	*324.72*
Food manufacturing	*2.2*	*12.99*	*714.38*
Packaging	*0.8*	*4.72*	*259.78*
Transport including overseas	***2.5***	***14.76***	***811.80***
Home food related	*2.1*	*12.40*	*681.91*
Retail	*0.9*	*5.31*	*292.25*
Catering	*1.5*	*8.86*	*487.08*
Waste disposal	*0.3*	*1.77*	*97.42*
Total	100	590.40	32,472.00

4.2.1 Food transport

Around 13.3% of GHG emissions in the UK food chain are attributed to commercial transportation of food for UK consumption (see Figure 4-1). As Figure 4-2 shows, overseas transport accounts for 53% of UK GHG emissions, which confirms that the UK is a net importer of many foods. The foodstuffs that most contribute to the overseas transport emissions are fruit and vegetables, since the UK is only 12% self-sufficient in fruit and 60% in vegetables (estimated with data from Defra (2011b), for calculations see Appendix B).

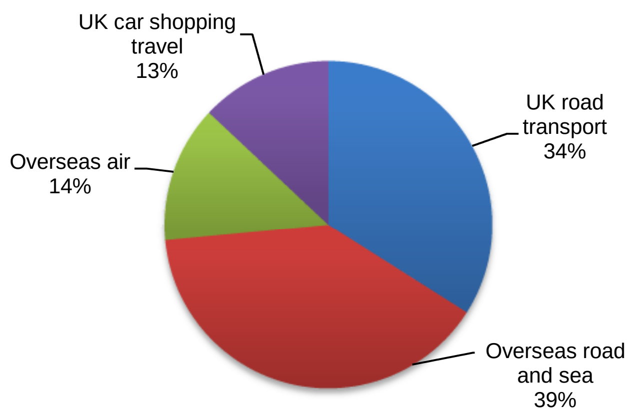

Figure 4-2: Transport emissions from the food chain in the UK. (Source: Defra (2007) cited in The Cabinet Office (2008b)).

4.2.1.1 Environmental and economic impacts of transportation of fruit and vegetables

The UK's low self-sufficiency in fruit and vegetables is responsible for the differences in the breakdown of the emissions by means of transport between the general food chain (Figure 4-2) and the fruit and vegetables sector (Figure 4-3).

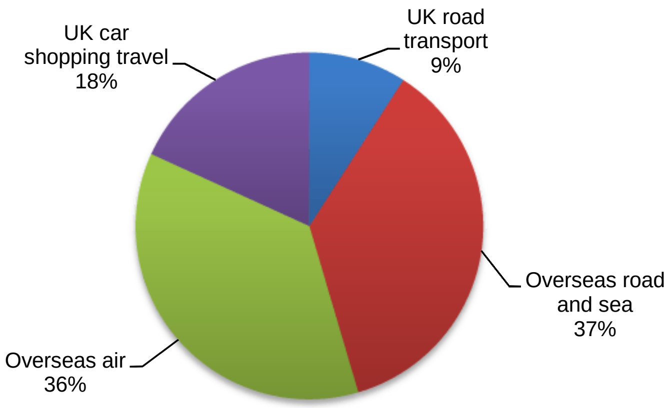

Figure 4-3: Contribution per means of transportation to the GHG emissions from the fruit and vegetable sector in the UK

Fruit and vegetables transport related emissions *as a whole* (including both imported and indigenously produced food) account for 0.55% of the UK's total GHG emissions. Despite this not being a high percentage, Figure 4-3 shows that transport is a significant life cycle stage for the fruit and vegetable sector, particularly if the produce comes by air, since only 1.5% of fruit and vegetables are air freighted (Garnett, 2007), whereas it accounts for 36% of total UK fruit and vegetable transport emissions.

Table 4-7 shows the emissions resulting from each means of transportation for fruit and vegetables and the economic implications taking 590.4 Mt CO_2e as UK total GHG emissions (figure for year 2010; DECC, 2012) and 55£/tC as the SPC (DECC, 2011).

Table 4-7: GHG emissions and economic costs for each means of transportation for fruit and vegetables in the UK. (Source: Based on Garnett (2006)).

	Contribution to UK GHG total (%)	t CO_2e/year	Economic cost UK (million £/year)
UK road transport	0.05	295,200	16.24
Overseas road and sea	0.2	1,180,800	64.94
Overseas air	0.2	1,180,800	64.94
UK car shopping travel	0.1	590,400	32.47
Total	0.55	3,247,200	178.60

4.2.2 Agricultural practices

4.2.2.1 Environmental and economic impacts of reducing the consumption of livestock products

About 7.4% of UK GHG emissions are attributable to agriculture, equivalent to 43.69 Mt of CO_2e (see Table 4-6) as carbon dioxide (11%), methane (36%) and nitrous oxide (53%) (Audsley *et al.*, 2009a). Much of this (57%) is dominated by emissions from the livestock sector (WWF and FCRN, 2009). Nevertheless, not all types of livestock have the same impact, as the meat from monogastric animals, known as “white meat” (poultry and pig meat), is less carbon intensive than the meat from ruminants, known as “red meat” (beef and sheep meat) (CCC, 2010). The Committee on Climate Change commissioned Cranfield University to assess the scope for emissions reduction through consumption change away from red and white meat and dairy products, and three scenarios were designed, summarized in Table 4-8.

Table 4-8: Dietary scenarios (the consumption of products compared with the actual consumption in 2005). (Source: Based on Audsley *et al.* (2009b)).

	Item	Relative consumption
Scenario 1 A 50% reduction in livestock product supply balanced by increases in plant commodities.	Milk and eggs	60%
	Meat	36%
	Sugar	70%
	Vegetables/fruits	150%
	Cereals/potatoes	133%
	Vegetable oils (not palm)	133%
	Beer, wine, beverages, cocoa, palm oil, fish	100%
Scenario 2 A shift from red to white meat, with no overall reduction in livestock consumption.	Milk and eggs	100%
	Cow and sheep	25%
	Pig and poultry	145%
	Sugar	100%
	Vegetables/fruits	100%
	Cereals/potatoes	100%
	Vegetable oils (not palm)	100%
	Beer, wine, beverages, cocoa, palm oil, fish	100%
Scenario 3 A 50% reduction in white meat supply balanced by increases in plant commodities.	Milk and eggs	100%
	Cow and sheep	100%
	Pig and poultry	50%
	Sugar	90%
	Vegetables/fruits	110%
	Cereals/potatoes	110%
	Vegetable oils (not palm)	110%
	Beer, wine, beverages, cocoa, palm oil, fish	100%

Table 4-9 shows the impact on emissions of each scenario (Audsley *et al.*, 2009b). All three scenarios reduced GHG emissions from primary production, with the largest reduction (18.59% less emissions) achieved by livestock reduction (Scenario 1), with the second largest achieved by a shift from red to white meat (Scenario 2) and the least effective scenario achieved through a 50% reduction in white meat consumption (Scenario 3).

Table 4-9: Agriculture GHG emissions associated with current UK consumption patterns and consumption change scenarios. (Source: Based on Audsley *et al.* (2009b)).

	Baseline 2010		Scenario 1		Scenario 2		Scenario 3	
	$MtCO_2e$/ year	% with respect to baseline	Mt CO_2e/ year	% reduction in emissions with respect to baseline	Mt CO_2e/ year	% reduction in emissions with respect to baseline	Mt CO_2e/ year	% reduction in emissions with respect to baseline
Within the UK	51.7	100	36.3	29.79	45.8	11.41	49.5	4.26
Overseas	29	100	29.4	-1.38	27.6	.83	28.5	1.72
Total UK agriculture emissions	80.7[1]	100	65.7	18.59	73.4	9.05	78	3.35

[1]Note: UK agriculture emissions in 2010 do not correspond to the estimated figures in Table 4-6 because in this table *on-farm production emissions* and *upstream emissions associated with fertiliser production* are included.

The economic impact of the agriculture GHG emissions in each consumption scenario was calculated using the SPC (55£/tC) (DECC, 2011) (Table 4-10).

Table 4-10: **Economic cost of agriculture GHG emissions associated with current UK consumption patterns and consumption change scenarios. (Source: Based on Audsley *et al.* (2009b)).**

	Baseline 2010		Scenario 1		Scenario 2		Scenario 3	
	Mt CO_2e/ year	Economic cost of emissions (million £)	Mt CO_2e/ year	Economic cost of emissions (million £)	Mt CO_2e/ year	Economic cost of emissions (million £)	Mt CO_2e/ year	Economic cost of emissions (million £)
Within the UK	51.7	2,843.5	36.3	1,996.5	45.8	2,519	49.5	2,722.5
Overseas	29	1,595	29.4	1,617	27.6	1,518	28.5	1,567.5
Total UK agriculture emissions	80.7	4,438.5	65.7	3,613.5	73.4	4,037	78	4,290

4.2.3 Health impacts from Scenario 1

Under Scenario 1 (see Table 4-8), the UK guidelines for a healthy diet would be met, therefore a number a health benefits would be achieved. The reason for this is because of the reduction of meat consumption and increase in fruit and vegetable intake that the scenario provides. Table 4-11 presents the results obtained in a review conducted by Scarborough *et al.* (2012b) which quantified the number of deaths that could be avoided if the UK dietary recommendations were followed. As shown in Table 4-8, the UK guidelines for a healthy diet would be met under Scenario 1. Given this, it was assumed that a total of 33,157 deaths due to ischaemic heart disease, stroke and cancer could be avoided, resulting in a 5.9% reduction in the overall mortality for the UK.

Table 4-11: Potential reduction in deaths by achievement of UK general dietary recommendations by disease. (Source: Based on Scarborough *et al.* (2012b)).

	Deaths	% all deaths UK
Ischaemic heart disease	20,800	3.7
Stroke	5,876	1.0
Cancer[1]	6,481	1.2
Total	33,157	5.9

[1] Types of cancer considered: oesophagus, colorectal, gallbladder, pancreas, breast, endometrial, kidney, mouth/larynx/pharynx, stomach and lung.

4.2.3.1 Health benefits of increasing fruit and vegetable intake

An increase of 50% in the current consumption of fruit and vegetables, as specified in Scenario 1 would meet the recommended 400g person^{-1}day^{-1} (5 portions a day). The health implications of this consumption change scenario would be significant, since according to Scarborough *et al.* (2012b) if the UK population met the target of the '5 A Day' program, 15,177 deaths due to ischaemic heart disease, stroke and cancer could be avoided, reaching a reduction in mortality of 2.7% (See Table 4-12).

Table 4-12: Potential reduction in deaths by achievement of dietary recommendations of fruit and vegetables by disease. (Source: Based on Scarborough *et al.,* (2012b)).

	Deaths	% all deaths UK
Ischaemic heart disease	7,053	1.3
Stroke	3,383	0.6
Cancer[1]	4,741	0.8
Total	15,177	2.7

[1] Types of cancer considered: oesophagus, colorectal, gallbladder, pancreas, breast, endometrial, kidney, mouth/larynx/pharynx, stomach and lung.

4.2.3.2 Health benefits of reducing the consumption of meat

The percentage of colorectal cases diagnosed in 2010 in the UK attributable to consumption of red meat was estimated in 21.1% (Parkin, 2011). This means that under Scenario 1, which calls for a 50% reduction in red meat consumption, the number of colorectal cases diagnosed per year would decrease substantially. Considering 39,914 cases diagnosed in 2010 (Parkin and Boyd, 2011b), 10.5% of them could be avoided if the consumption of livestock products was reduced by 50%, as shown in Table 4-13.

Table 4-13: **Colorectal cancer cases avoided under Scenario 1. (Source: Parkin (2011), Parkin and Boyd (2011b)).**

No. cases diagnosed in 2010	39,914
Of which, due to red meat consumption (Baseline)	8,422
Avoided cases under Scenario 1	4,211

Other health benefits associated with the reduction of the meat consumption in the UK would be a lower risk of developing several diseases such as type 2 diabetes (Fretts *et al.*, 2012; Van Woudenbergh *et al.,* 2012), stroke (Larsson *et al.*, 2011) or cardiovascular disease (Heidemann *et al.*, 2008; Friel *et al.*, 2009).

Regarding caridovascular disease, Heidemann *et al.* (2008) carried out a study of the impacts that red meat consumption has in terms of public health, finding that it increases the risk of mortality from ischaemic heart disease by 22%. As in the calculations for colorectal cancer cases in Table 4-13, under

Scenario 1, the risk of mortality from ischaemic heart disease would be reduced by 50% over the number of deaths attributable to red meat consumption. This would lead to the estimated avoided deaths shown in Table 4-14.

Table 4-14: Potential reduction of deaths from ischaemic heart disease under Scenario 1.

No. deaths from ischaemic heart disease in 2010	80,534[1]
Of which, due to red meat consumption (Baseline)	17,718[2]
Avoided deaths under Scenario 1	8,859

[1] ONS (2011), NISRA (2011) and General Register Office for Scotland (2011) [2] Heidemann *et al*. (2008)

4.2.3.3 Health benefits of reducing the sugar content in diet

The 30% reduction in sugar content in Scenario 1, together with the reduction in fats resulting from lowering the meat consumption, and the increase in fibre intake derived from the increase in fruit and vegetable consumption, would provide significant benefits for public health, especially in terms of obesity problems. The combination of these nutritional enhancements would reduce substantially the burden of disease attributable to high BMI, although this has not been quantified for this study due to lack of data and time. The NHS would however save very large sums of money each year if the UK population met the dietary requirements proposed in Scenario 1.

4.3 Summary

The results obtained in this study have quantified the health and environmental burden derived from an unhealthy diet in the UK. In this section, the impacts of poor diet on health are summarised.

4.3.1 Diet and health

The NHS expenditure for treating the consequences of obesity (Table 4-3) is large at £5,655 million per year. A detailed analysis (Table 4-5) to find out the expenditure incurred for each obese patient for different diseases related with high BMI was undertaken, showing that the treatments for ischaemic heart disease, osteoarthritis and the first years after diagnosis from corpus uteri cancer and colorectal cancer are very costly. This suggests that an improvement in the UK diet will lead to a reduced incidence of obesity and therefore a significant saving in the treatment of several chronic diseases for the NHS.

In addition, due to the nutritional enhancement of the UK diet that Scenario 1 in the study for the CCC (Audsley *et al.,* 2009b) proposes, there would be substantial benefits for health, that have been detailed in section 4.2.3.

From the calculations made for the preventable mortality under a diet within the UK dietary recommendations, it was found that 33,157 premature deaths could be avoided if general UK guidelines were met (Table 4-11). However, when comparing Table 4-11 with Table 4-12, it was observed that half of them could be avoided by only meeting the ‘5 A Day’ target. Therefore the effectiveness of this measure was confirmed and it can be concluded that its compliance could help significantly reduce the burden of disease and mortality attributed to some of the major diseases affecting the UK population. Furthermore, if individual fruit and vegetable consumption was increased to 600g $person^{-1}day^{-1}$ (equivalent to 7.5 standard portions), reaching the intake levels of the highest consuming countries such as Greece, Spain or Italy, the burden of ischaemic heart disease could be reduced by up to 17% in Europe (Pomerleau *et al.*, 2006).

Regarding the consumption of red and processed meat, its association with two specific diseases has been quantified. It has been found that 4,211 premature deaths from colorectal cancer and 8,859 from ischaemic heart disease could be avoided each year under Scenario 1.

For a better understanding, all these benefits on health are summarised in Table 5-1.

Table 4-1: Health implications of the current consumption levels of fruit and vegetables and red/processed meat; and benefits from changing to consumption Scenario 1.

Diseases	Diet low in fruit and vegetables	Diet high in red/processed meat	Overall outcome from Scenario 1
Ischaemic heart disease	7,053 deaths per year	17,718 deaths per year (22% more risk of mortality)	*If only fruit and vegetables and red/processed meat are considered:* 7,053 + 8,859[2]=15,912 deaths avoided per year
			If more nutrition aspects are considered (i.e. salt, fibre, fats) according to Scarborough et al. (2012b): 20,800 deaths avoided per year
Diabetes	Not quantified	Higher risk of developing type 2 diabetes	Lower risk of developing type 2 diabetes
Stroke	3,383 deaths per year	Higher risk of having a stroke	3,383 deaths avoided per year Reduction in the number of cases diagnosed per year
Cancer	4,741[1] deaths per year	8,422 cases of colorectal cancer diagnosed per year (21.1% of all colorectal cancer cases diagnosed per year)	*If only fruit and vegetables and red/processed meat are considered:* 4,741 + 4,211[2]= 8,952 deaths avoided per year Most significant impact on the incidence of colorectal cancer (at least 4,211[2] less cases)
			If more nutrition aspects are considered (i.e. salt, fibre, fats) according to Scarborough et al. (2012b): 6,481 deaths avoided per year

1 Types of cancer considered: oesophagus, colorectal, gallbladder, pancreas, breast, endometrial, kidney, mouth/larynx/pharynx, stomach and lung.

2 The avoided deaths in Scenario 1 from ischaemic heart disease and the reduction in the number of cases of colorectal cancer diagnosed each year are half the amount attributable to red/processed meat consumption because Scenario 1 assumes a 50% reduction in red meat consumption, and as long as a diet contains red meat, even if little amount, there is risk of developing several chronic diseases.

4.3.2 Diet and sustainability

Not only are the current dietary patterns of the UK unhealthy, but they also contribute significantly to GHG emissions. Therefore, the UK diet is "neither sustainable for health nor the environment" (WWF, 2011).

As has been shown in section 4.2, the most contributing sectors to the UK GHG emissions resulting from the food system are transport and agriculture. From the results obtained it could be said that reducing livestock consumption by 50% and replacing it with an increase in plant commodities offers the most effective way to reduce the carbon footprint of the UK food consumption, although this single measure will not by itself cut emissions by 70%. Other measures are needed in order to meet the target set out by the 2008 Climate Change Act, like the ones suggested by Friel *et al.* (2009): increased carbon capture through change of land use, improved manure management and decreased dependence on fossil-fuel inputs.

Table 5-2 summarises the nutritional, environmental and economic benefits achieved by changing the current consumption patterns to Scenario 1 designed by Audsley *et al*. (2009).

Table 4-2: **Benefits obtained under consumption change Scenario 1.**

	Baseline (current consumption patterns)	**Scenario 1**
Nutritional characteristics	Too much saturated fat, salt and sugar. Too little fruit, vegetables, wholegrains and oily fish.	Reduction in meat, milk, eggs and sugar consumption. Increase in fruit, vegetables, cereals, potatoes and vegetable oils consumption.
Agriculture GHG emissions	80.7 $MtCO_2e$/year	65.7 $MtCO_2e$/year (18.59% reduction)
Economic cost associated	£ 4,438.5 million	£ 3,613.5 million (Saving of £825 million)

A shift to consumption Scenario 1 would have significant economic implications, since the savings achieved would reach around £825 million, not to mention the economic savings in NHS expenditure derived from the diseases related to current UK dietary patterns, in which the livestock sector makes a high contribution whereas the fruit and vegetables consumption is below the recommendations.

However, an increase in fruit and vegetable consumption would entail an increase in the GHG emissions resulting from their transportation. Locally produced fruit and vegetables should be promoted as far as possible to reduce the problem of 'food miles' associated with them. Even if UK land and weather conditions do not allow certain products to be grown, the establishment of local shops to reduce the distance they have to travel between the farm and the consumer's plate, would help reduce the carbon footprint of the food transport sector.

Finally, land capability and constraints have to be considered. Audsley *et al.* (2009) analysed to what extent a change in the UK consumption of livestock products would release land available for other purposes like production of substitute goods, biomass production or forestry. All consumption change scenarios defined by Audsley *et al.* (2009b) reduced the total amount of land required to support the UK food system. Under consumption Scenario 1, there would be a significant release of land currently used for livestock production that has some potential for other agricultural uses. This land use change could bring potential environmental benefits and substantial opportunities to deliver other products, although it would also involve a loss of employment and skills in rural areas, as well as having negative impacts in linked industries such as the meat processing sector (Audsley *et al.,* 2009). However, in order to achieve a reduction in meat consumption required for improving public health and the environment, some trade-offs need to be made.

4.4 Future research

Future research is required to complete the analysis provided in this study.

This study considered two aspects of the UK diet: low intake of fruit and vegetables and the high intake of meat. However, the nutritional deficiencies of the UK diet also include low intake of fibre and high intake of salt, sugar and fat. Future research should also examine the economic costs and savings on the NHS and society in general, if all these dietary requirements were met.

The difficulty in finding economic data on obesity and obesity mitigation means that estimates of potential economic savings for the NHS are associated with uncertainty under the consumption patterns provided by Scenario 1. An analysis of the costs and benefits has been provided in section 4.2.3.3, but it is recommended that specific data for calculating the linkage between sugar, fat intake and obesity is developed to improve the analysis.

5 CONCLUSIONS

This study has revealed the substantial costs of poor diet in terms of its health and environmental effects.

Poor diet is heavily implicated in the incidence of several illnesses in the UK. Lifestyle-related ill health is caused by a combination of factors, like little physical activity and unhealthy dietary habits among the British population. The average diet in the UK is considered to be a poor diet due to its nutritional deficiencies and excesses. The major issues related to this are obesity and overweight, which are becoming a real challenge for the UK due to the rapid increase in their incidence. Therefore, obesity is a growing health concern in the UK due to its harmful effects on health, the environment and because of its economic cost. This study has confirmed the enormous economic costs that poor diet and obesity impose on society, not only on the NHS, but also on businesses and society due to lost productivity.

The implementation of certain policy measures to promote healthy eating, already applied successfully in several countries, could help tackle obesity. Some of these have been effective in improving consumer behaviour. These include public information campaigns like the well-known '5 A Day' program in the UK and its equivalent in Italy, or nutritional education programs like those carried out in Italy and Scotland. The more effective measure confirmed to date has been the '5 A Day' message, since the evidence suggested that this achieved an increase from 3.7 to 4 portions per person per day between 2003 and 2011. If more measures promoting a healthy and balanced diet were imposed, the economic, social and individual costs of obesity and overweight could be reduced, as well as the environmental damage that the provision of such diet imposes.

However, the UK Government still needs to be convinced to broaden its policy on diet. Policy interventions implemented so far are more focused on directing consumers to locally and seasonally produced fruit and vegetables rather than reducing the consumption and production of food from animal sources. This analysis has shown that a healthy diet can also be environmentally, socially and economically sustainable. But achieving the change in diet needed will require large efforts from Government, producers and consumers.

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APPENDICES

Appendix A Value of Carbon Emissions

A.1 Total UK GHG Emissions

UK Greenhouse Gas Emissions 1990-2011 weighted by GWP (Mt CO_2e). (Source: DECC (2012)).

		1990	1995	200	2005	2006	2007	2008	2009	2010	2011 (p)
Net CO_2 emissions (emissions minus removals)	Energy supply	242.5	211.5	203.4	217.6	223.4	219.3	212.8	189.8	195.7	183.8
	Business	110.6	104.5	104.2	94.1	91	89.3	87.5	76	75.6	69.6
	Transport	119.4	119.6	124.6	128.8	129.2	130.9	126.4	120.9	120.6	118.9
	Public	13	12.7	11.5	11	10	9.3	9.3	8.2	8.4	7.9
	Residential	79	80.8	87.1	84.3	81.7	78.1	79.9	74.7	86.5	67.5
	Agriculture	5.2	5.3	4.8	4.6	4.3	4.1	4.1	4.1	4.1	4.1
	Industrial process	16.3	15	14.8	14.2	13.3	14.6	13.3	8.6	9	8.7
	Waste Management	1.2	0.9	0.5	0.4	0.3	0.3	0.3	0.3	0.3	0.3
	LULUCF	3.1	1.6	-0.4	-3.7	-3.8	-4.2	-4.6	-4.9	-4.5	-4.5
	Total CO_2	590.3	552	550.5	551.2	549.4	541.8	529	477.8	495.8	456.3
Other greenhouse gases		179	158.4	121.6	101.3	98.5	96.3	94.6	91.8	92	90.4
Kyoto greenhouse gas basket		766.4	708.4	671.5	654.7	650.3	640.9	626.7	572.5	590.4	549.3

Notes
1. Figures shown for 2011 are provisional.
2. Provisional 2011 CO_2 emissions for the agriculture, waste and LULUCF sectors have not been estimated; 2010 estimates have been used for this component of the provisional estimates of total UK emissions.
3. Kyoto basket total differs slightly from sum of individual pollutants above as the basket uses a narrower definition for LULUCF, and includes emissions from UK Overseas Territories.
4. Emissions are presented as carbon dioxide equivalent in line with international reporting and carbon trading. To convert carbon dioxide into carbon equivalents, divide figures by 44/12.
5. The entire time series is revised each year to take account of methodological improvements in the UK emissions inventory.

A.2 Shadow Price of Carbon

Summary of all carbon values and sensitivities over the 2008-2050 period (Real £2011). (Source: DECC (2011)).

		Traded			Non-traded	
Year	**Low**	**Central**	**High**	**Low**	**Central**	**High**
2008[1]	19	19	19	27	53	80
2009[1]	12	12	12	27	54	81
2010[1]	13	13	13	27	55	82
2011	6	13	17	28	56	83
2012	7	14	18	28	56	85
2013	9	16	20	29	57	86
2014	10	17	21	29	58	87
2015	12	19	24	30	59	89
2016	14	21	27	30	60	90
2017	15	22	28	30	61	91
2018	16	24	31	31	62	93
2019	17	26	33	31	63	94
2020	19	29	35	32	64	95
2021	21	33	43	32	65	97
2022	23	38	51	33	66	99
2023	25	42	58	33	67	100
2024	26	47	66	34	68	102
2025	28	51	73	34	69	103
2026	30	56	81	35	70	105
2027	32	61	89	36	71	107
2028	34	65	96	36	72	108
2029	35	70	104	37	73	110
2030	37	74	111	37	74	111
2031	41	81	122	41	81	122
2032	44	88	132	44	88	132
2033	47	95	142	47	95	142
2034	51	102	153	51	102	153
2035	54	109	163	54	109	163
2036	58	116	173	58	116	173
2037	61	122	184	61	122	184
2038	65	129	194	65	129	194
2039	68	136	204	68	136	204
2040	72	143	215	72	143	215
2041	75	150	225	75	150	225
2042	78	157	235	78	157	235
2043	82	164	246	82	164	246
2044	85	171	256	85	171	256
2045	89	178	266	89	178	266
2046	92	184	277	92	184	277
2047	96	191	287	96	191	287
2048	99	198	297	99	198	297
2049	103	205	308	103	205	308
2050	106	212	318	106	212	318

1 2008, 2009, 2010 traded prices are based on actual EU ETS prices.

Appendix B UK fruit and vegetable production

UK self-sufficiency in fruit and vegetable production. (Source: Defra (2011b)).

	Fruit	Vegetables
Home Production Marketed (HPM) ***(tonnes)***	415,700	2,659,200
Imports ***(tonnes)***	3,173,200	1,854,900
Exports ***(tonnes)***	145,700	79,300
Consumed ***(tonnes)***	3,443,200	4,434,800
Self-sufficiency ***(%)***	12.07	59.96

Appendix C Gross Domestic Product deflators

Original GDP deflator at market prices. Reference financial year: 2006-07. (Source: HM Treasury (2012)).

Financial year	GDP deflator at market prices	
	2006-07 = 100	per cent change on previous year
2006-07	100.000	2.69
2007-08	102.492	2.49
2008-09	105.290	2.73
2009-10	106.873	1.50
2010-11	109.908	2.84
2011-12	112.528	2.38

GDP deflator at market prices. Reference financial year: 2011-12. (Source: Adapted from HM Treasury (2012)).

Financial year	GDP deflator at market prices	
	2011-12 = 100	per cent change on previous year
2006-07	88.867	2.69
2007-08	91.082	2.49
2008-09	93.568	2.73
2009-10	94.975	1.50
2010-11	97.672	2.84
2011-12	100.000	2.38