Behavioural Climate Change Mitigation Options

Domain Report Food

Report
Delft, April 2012

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Preface

This is the final report on *Behavioural Climate Change Mitigation Options in the Food Domain*. It is part of the study *Behavioural Climate Change Mitigation Options and Their Appropriate Inclusion in Quantitative Longer Term Policy Scenarios* for the European Commission, DG Climate Action. The aim of the study is threefold:

1. To assess and demonstrate the GHG emission reduction potential of changes in behaviour and consumption patterns.
2. To analyse policy options for the further development of community policies and measures inducing changes in behaviour and consumption patterns. And
3. To identify the linkages with other technical and economic variables in such a way that it can be used in modelling and scenario development.

The study has focused on three domains: transport, food and housing.

This report is part of five reports which together constitute the final report of the contract 070307/2010/576075/SER/A4. The other reports are:

1. The Main Final Report.
2. The Transport Domain Final Report.
3. The Housing Domain Final Report.
4. A Technical Report on the appropriate inclusion of results of the analysis in model-based quantitative scenarios.

The study has been conducted by a consortium led by CE Delft comprising of Fraunhofer ISI and LEI.

Jasper Faber

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Summary

Food and drink production and consumption contributes substantially to GHG emissions. Many changes in dietary choices can be identified that could contribute to reduced emissions from agriculture and food production. Based on a review of the literature we identified the three most important ones (in terms of abatement potential and policy relevance):

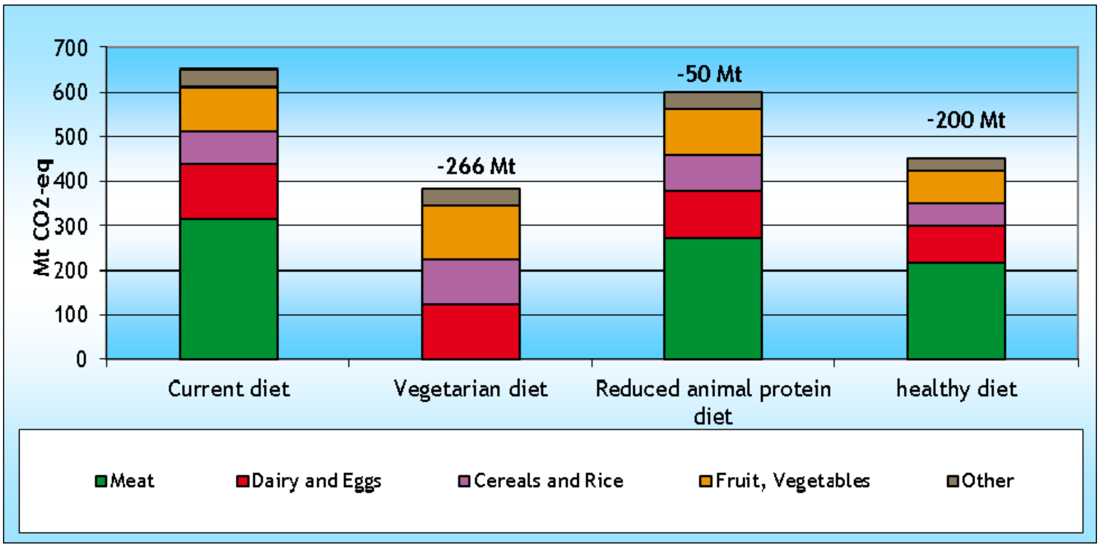
- Vegetarian diet: no consumption of meat, fish or seafood. The calorie intake is constant, meat, fish and seafood are replaced by calorie-equivalent amounts of grains, legumes and vegetables. All other categories including dairy products and eggs remain unchanged.
- Reducing all animal protein intake including dairy and eggs: one day without animal proteins. The consumption of meat, fish, seafood, dairy products and eggs is reduced by 14%. As in the vegetarian diet, the calorie intake is constant. Animal proteins are replaced by calorie-equivalent amounts of grains, legumes and vegetables.
- Reducing intake to a healthy level (calories, overall protein): reducing daily intake to 2,500 kilocalories and eating 500 grams of fruits and vegetables, in line with WHO/FAO recommendations. This in turn limits the total fat to 30% of caloric intake and saturated fatty acids to 10%, reducing sugar intake to 10% of total caloric intake and limiting salt intake to a maximum of 5 grams per day.

For these three behavioural changes we carried out detailed assessments to estimate their abatement potential, identify the main barriers inhibiting their implementation and identify policy instruments that could be used to overcome the main barriers. Finally, for two behavioural changes (healthy diet and reduced animal protein intake) an assessment of the effectiveness of selected policy packages is carried out.

GHG abatement potential

The reduction potential of a vegetarian diet is larger than that of the other two diets, mainly because almost half of the direct life cycle emissions from the current diet are associated with meat consumption. Healthy eating results in a somewhat smaller reduction in direct life cycle emissions, while a 14% reduction in animal protein has the smallest abatement potential of the dietary changes considered (Figure 1).

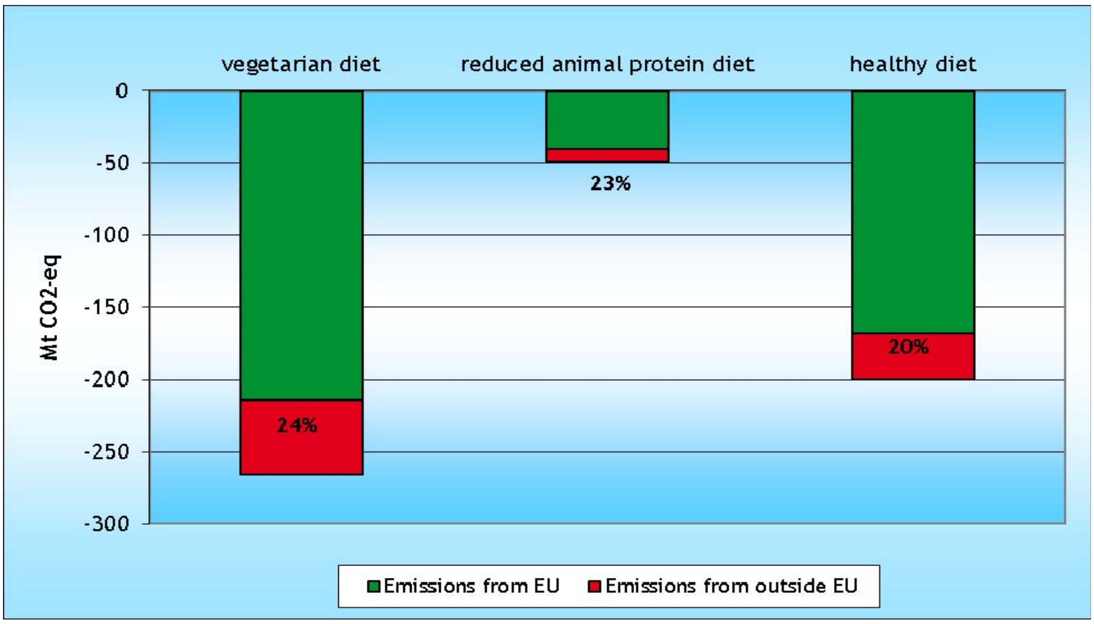
Figure 1 Total climate impact in current and selected diets in 2020, Mt of CO_2 eq.



The maximum realistic emission reduction potential in 2030 and 2050 is about the same, as the EU population is projected to be relatively stable.

In all dietary changes considered, most of the life cycle emission reductions occur in the EU. The share of emission reductions outside the EU varies from 20% for the healthy diet option to 24% for the vegetarian diet.

Figure 2 Maximum realistic emissions reductions potential of diet shifts, with division into EU and non-EU emissions



Overview of barriers
For vegetarian and reduced animal protein diets, knowledge, habits and cultural barriers are the most important barriers. It is likely that, once knowledge levels, habits and culinary cultures have changed, products for meat and animal protein products will become available in the food service sector and in meals and products that are ready-made and easy to produce. Situational and infrastructural barriers are less important than knowledge, habits and cultural barriers. Economic barriers are not relevant, since a vegetarian or reduced meat diet is typically cheaper than a conventional diet.

One important question is whether the barriers are equally important for a vegetarian diet and a reduced animal protein diet. Because changing to a vegetarian diet constitutes a big change as compared to most consumers' current diets, whereas reducing animal protein intake to six days a week constitutes a more limited change and essentially leaves the diet intact on six out of seven days, we assume that habits and cultural barriers are slightly more important for a vegetarian diet than for reducing animal protein intake.

Table 1 Ranking of the barriers based on their relative impact for vegetarian and reduced animal protein diet

Barrier category	Examples
Individual (internal) barriers	
Knowledge-based barriers	– Consumers can sometimes be confused by the use of different terminologies, such as organic, green, natural or environmentally friendly – Consumers have little knowledge as to what is sustainable and what is not – Consumers are not aware of the environmental effects of meat consumption
Unconscious behaviour	– Dietary choices are often habitual
Societal (external) barriers	
Structural and physical barriers	– In the food-service sector (restaurants, cafés, street vendors) the availability of substitution products may be a problem
Cultural barriers	– Meat is a vital part of culinary cultures in Europe – Many people see meat as an essential part of the meal

Knowledge based barriers can be addressed through communication, e.g. mass media campaigns and food labelling. However, there is still the fact that food choices are in large part habitual. A first relevant policy instrument that addresses this consists of school-based intervention programs. Habits develop early in life, and it is therefore important to help children develop healthy and sustainable habits at a young age. Another way in which habits can be targeted is by using 'upstream' interventions, such as charging meat/animal protein consumption with consumption taxes.

The main barriers for a healthy diet are that many consumers do not have adequate knowledge about the healthiness of specific food products. Second, even when consumers have sufficient knowledge and are motivated to start a healthy diet, it will be very difficult to change the existing habit. Third, the abundance of food products on offer, and especially of unhealthy products, is an important infra-structural barrier.

Research reliably shows that the diets of people with low socio-economic status are less healthy than the diets of those with high socio-economic status. This consumer segment is the hardest to target.

Knowledge barriers can be addressed through food labelling, school-based intervention and mass media campaigns. Food Since habits form early in life, school-based interventions are also an effective way to address them. Taxes may also be used to change habits, while they can at the same time change the food on offer.

Policy packages

A shift towards a healthy diet could be induced through a policy package comprising of:

- regulation introducing mandatory nutrition labelling;
- financing school-based intervention programs and education of healthy eating;
- introducing consumption taxes.

This package is projected to result in a change in behaviour that can bridge about 22% of the gap between current diets and a healthy diet in 2020, increasing to 28% in 2050 as an increasing share of the population will have gained experience with the school-based intervention. The associated reduction in emissions would amount to 44 Mt CO_2e in 2020, of which 37 Mt CO_2e in the EU, increasing to 56 Mt CO_2e in 2050, of which 47 Mt CO_2e in the EU.

In order to reduce the animal protein intake, a policy package could be introduced comprising of:

- an animal protein tax or excise duty;
- sustainability labelling.

A quantification of the effect of this package is hampered by the lack of empirical evidence on the effects of sustainability labelling and possible other policy measures, such as mass-media campaigns and school-based interventions. While these measures can be effective in a shift towards a healthy diet, it is uncertain whether they can also incentivise a shift to a more sustainable diet. In view of the absence of empirical evidence, this report has chosen not to include these measures in the policy package. The remaining measures are projected to result in a change in behaviour that can bridge about 5.5% of the gap between current diets and a reduced animal protein diet. The associated reduction in emissions would amount to 3 Mt CO_2e, of which 3 Mt CO_2e in the EU. These amounts are relatively stable over time.

1 Introduction

1.1 Background to the project

The EU's greenhouse gas (GHG) emission reduction policies and the goal to keep the global temperature increase below 2°C commits the EU as a whole to reduce emissions by at least 20% below 1990 levels by 2020, and by 80-95% by 2050.

The current models for quantitative assessments of climate policies are implicitly or explicitly focused on technical mitigation measures and on behavioural changes induced by market based instruments. For example, the Low Carbon Economy Roadmap assesses the impacts of technology changes in agriculture on emissions and the impacts of changes in the Common Agricultural Policy, but does not discuss changes in demand for different agricultural products. From these models, it is clear that there is a considerable potential to reduce emissions, both in the ETS and in the non-ETS sectors. However, they also show that reaching ambitious targets in some non-ETS sector by conventional means may become quite costly.

An emerging body of literature shows that changes in consumption patterns can achieve considerable reductions in emissions at relatively low costs. This body of literature focuses on the emission reduction potential of behavioural changes, associated costs, and barriers to these changes and policy instruments to overcome these barriers. Many of these studies are case studies or qualitative assessments, and hence the results are not yet translated into scenarios or policy assessment models.

The Low Carbon Economy Roadmap acknowledges that behavioural changes may be needed to reach the emissions targets or that the targets may be reached at lower costs of behavioural change would occur (see also the accompanying impact assessment SEC(2011) 288 final).

Because of the importance of behavioural changes, this study assesses their impacts on GHG emissions. It also analyses which barriers exist to behavioural changes, whether policies can help overcoming these barriers and if so, to which extent.

1.2 Objective of this report

This report presents the results on the assessments made on behavioural changes in the food domain. The main behavioural changes (in terms of mitigation potential) are identified and for a selection of these options an analysis of GHG mitigation potential, barriers and policies is carried out.

1.3 Outline of the report

In Chapter 2 we provide a broad overview of behavioural dietary changes. Based on a broad assessment of mitigation potentials of these behavioural changes, we select three of them for further investigation in the remainder of the study. In Chapter 3 a detailed assessments of the abatement potential of the three selected behavioural changes are presented. Additionally, cost and co-benefits are discussed. The main barriers inhibiting the selected behavioural changes are discussed in Chapter 4, as well as relevant consumer segments and policy instruments. Additionally, a broad overview of policy instruments that could be implemented to address the barriers is given. Finally, in Chapter 5 we discuss the effectiveness and implementation costs of policy packages for facilitating some of the behavioural changes in the food sector.

2 Overview of diet change options

2.1 Introduction

Food and drink production and consumption contributes substantially to GHG emissions. Food patterns are however very difficult to change.

Behavioural options in this sector focus mostly on changing diet patterns, reducing food waste and eating more seasonal and local products. It should be noted that the effects of various dietary transitions are intertwined and reinforce each other, e.g. shifting to a vegetarian diet brings some GHG reduction but shifting to a diet with only locally produced vegetables brings a much stronger effect. Additional options include reducing energy use during shopping, preparation and storage of food – these options overlap with transport options and with more general energy saving options.

The options identified and the literature available on the topic are briefly discussed below.

2.2 Reduction of animal protein intake

Reducing consumption of meat could bring a substantial drop in GHG emissions. Dutilh and Kramer (2000) investigate energy requirement for various food products according to categories. They find that energy requirement for producing meat and diary products is about ten times higher than for local fruits and vegetables.

Popp et al. (2010) analyse non-CO_2 greenhouse gas emissions from agricultural production using a global land-use model MAgPIE. In the baseline scenario, i.e. with constant share of animal products in human diets, global agricultural non-CO_2 emissions are predicted to increase from 5,314 CO_2 eq. in 1995 to 8,690 CO_2 eq. in 2055. With the assumption that the share of meat products in human diets will be increasing together with increase in income ('increased meat scenario'), the results of the model run indicate that global agricultural non-CO_2 GHG emissions would increase by 76% as compared to the baseline scenario. However in the 'decreased meat scenario', where the demand for meat would be assumed to drop by 25% per a decade, global non-CO_2 emissions would decrease by 51% as compared to the baseline.

Carlsson-Kanyama (1998) studies GHG emissions and energy consumption during life cycles of carrots, tomatoes, potatoes, rice, pork and dry peas consumed in Sweden in order to calculate the potential for changing food consumption towards more sustainable emission levels. The results show that emissions of GHGs and energy consumption differ greatly between the different food items. For example, emissions of GHG related to pork production are nine times higher than the emissions related to peas, and emissions related to production of rice are 38 times higher than the emissions related to potatoes. Carlsson-Kanyama proposes to use the whole meals with similar nutritional qualities for comparison of the GHG-related burden.
It turned out that vegetarian food does not have to imply less emissions than food with meat content. The meal containing rice and tomatoes but no meat

generated about twice as much GHG emissions as the meal containing domestically produced meat and potatoes.

Stehfest et al. (2009) investigate various food patterns and their impact on GHG emissions using an integrated assessment model IMAGE. According to their estimates, vegan diet would results in about 17% reduction of GHG emissions worldwide (the reductions refer to cumulative emissions between 2010 and 2050). According to Blonk et al. (2008), if all Dutch people changed their diet to vegan, about 3% of annual reduction of Dutch GHG emissions would be achieved (and 4% of GHG emissions related to final consumption of goods).

2.3 Healthy diet: fewer calories, less protein

One of the options to reduce the energy content of food is to reduce average consumption per capita in countries where it exceeds the daily recommended rate (Pimentel et al., 2008). The average American consumes an estimated 3,747 kcal per day while The Food and Drug Administration (FDA) recommends an average daily consumption of 2,000 to 2,500 kcal a day. Reducing the calorie intake to a lower level would significantly reduce the energy used in food production.

According to CE and Blonk Milieu Advies (2010), theoretic shift of the whole population to a diet with reduced consumption of meat, fish and eggs, could reduce environmental impact of food by 25% (with 10% of the population shifting, 2.5% reduction could be achieved). Various dietary options are considered in this study, with the potential of lowering environmental burden of food by 13 to 25%. No specific climate change mitigation potential values are given, however. Also Stehfest et al. (2009) refer to the same type of healthy diet. According to their estimates, the healthy diet results in a reduction of GHG emissions of 10% as compared with the BAU scenario (the reductions refer to cumulative emissions between 2010 and 2050).

2.4 Reducing food waste

Food wastage can be divided into the category of unavoidable waste (un-edible remains) and waste which could be avoided (throwing away expired food, leaving edible food on the plate). The rate of food that is wasted differs depending on type of the product. For example, CE and Blonk Milieu Advies (2010) estimate waste during the storage of products at about 10% for fresh products and at only 2% for products with longer expiry dates, such as rice and pasta. Throwing food remains to garbage is related to the value of food, e.g. food with low value such as potatoes tends to be much more often thrown away. According to this study, reducing food waste by 20% (including packaging) would lower environmental burden of food by 3.5%. Reducing all food waste would lower environmental burden of food by 15.5%. Reducing food waste by 22% of weight at home and 40% outside home would lower environmental burden of food by 5.5%. Unfortunately, no specific climate change mitigation potential numbers are given in this study.

Weidema et al. (2008) investigate an option of better planning of food purchases, which would also contribute to less food wastage. It is estimated that food loss can be halved by application of better planning tools, and that these tools will be accepted by 25% of consumers, resulting in an average 12.5% reduction in food waste. CO_2 eq. reduction potential was estimated at the level of 11.7 Mt in the EU-27. Further work on food waste is ongoing in the European Commission outside the context of this study (BioIS et al., 2010, see also http://ec.europa.eu/food/food/sustainability/index_en.htm).

2.5 More percentage of local and seasonal food, reducing food imports

A few literature sources pay attention to the fact that local and seasonal food has on average much lower GHG emissions intensity. Dutilh and Kramer (2000) give estimates of energy requirement related to various types of food. It is evident that vegetables grown in greenhouses and products which are transported on long distances require much more energy input in their life cycle than locally produced food. Carlsson-Kanyama (2008) investigates CO_2 emissions that can be attached to various food products concluding that for example CO_2 eq. emissions related to production of rise are about 38 times higher than those related to growing potatoes. Sukkel et al. (2010) investigate local effects (for the city of Almere) of shifting to more locally produced food and using renewable resources, concluding that quite high reductions in CO_2 emissions can be achieved.

2.6 Reducing energy and fuel use

Another set of options related to the food sector would be reducing energy and fuel use. Energy use related to food in households can be cut the most by using more energy efficient cooling appliances and placing them in cool places such as a cellar. Fuel use can be reduced by more intensive use of the home delivery of groceries service. These options are investigated by Weidema et al. (2008). Dutilh and Kramer estimate factors of energy requirement related to various types of food and methods of preparation/transport. It is evident that products involving more transport, storage and cooling require more energy input and therefore, generate more GHG emissions.

2.7 Selection of behavioural change options

We have applied a three step process for selecting behavioural changes:

Step 1: Remove behavioural changes with poor data availability and lack of conceivable policy instruments

Behavioural changes with a poor data availability do not allow for the calculation of GHG emission reduction potential and costs. Behavioural changes for which no policy instrument is conceivable are excluded because they cannot contribute to the study objective to ‘analyse policy options for the further development of community policies and measures inducing changes in behaviour and consumption patterns’.

Step 2: Rank behavioural changes according to their mitigation potentials
In this second step the remaining behavioural changes are ranked based on their mitigation potential. The ranking process is complicated by the fact that for some behavioural changes the literature reviewed presented maximum potentials, while for other changes just 'realistic' potentials are given. In addition, the time horizon of the mitigation potential estimates differs between studies (and hence behavioural changes). Therefore, the ranking of the various behavioural changes was performed by expert judgement based on the results of the literature review.

Step 3: Select options that have a high policy relevance and/or are usually not covered by models
This step eliminates behavioural changes that have a relatively large GHG abatement potential but are already included in models, and changes that have a relatively large abatement potential but that are studied elsewhere or have little policy relevance for other reasons.

The selection process has resulted in the selection of three behavioural changes in the Food domain.

Food and drink
1. Vegetarian diet.
2. Reducing all animal protein intake including dairy and eggs.
3. Reducing intake to a healthy level (calories, overall protein).

The GHG impacts, costs and barriers of these behavioural changes are studied in more detail in the next chapters.

3 Abatement potential and costs

3.1 Selected behavioural changes

To develop insight in the mitigation potential of the three selected behavioural changes chosen in Chapter 1, we introduce a stepwise approach. First, we estimated the current EU-27 diet as a BAU scenario, after which we estimated the effects of the three behavioural changes on GHG potential. To determine the current EU-27 diet, we first identified four different European regions. These regions were based on geography, but also on established cultural dietary patterns. There are large differences between regions in the world, but also in the European Union, with regards to their established dietary patterns. With regards to animal protein consumption, for instance France, Portugal, Spain, Denmark and Sweden have the highest consumption of animal protein, whereas new member states of the European Union generally have lower per capita of animal proteins (PBL, 2011). In France, Portugal and Spain, animal protein consumption mainly consists of meat and fish, whereas in Denmark and Sweden, meat and dairy are responsible for most animal protein consumption. Estimation of the mitigation potential of the three selected behavioural changes needs to take these regional differences into account. Based on consumption projections from the FAO (FAO, 2006) we identified four European regions: North-West Europe, with high consumption of meat and dairy but low consumption of fish, South-West Europe, with diets high in meat and fish, but low in dairy, South-East Europe, with moderate consumption of meat and fish, and North-East Europe, with high consumption of dairy and moderate consumption of meat and fish.

The regions are:

Region 1: North-West Europe:
Sweden, Denmark, UK, Ireland, The Netherlands, Germany, Belgium, Luxembourg.

Region 2: South-West Europe:
France, Portugal, Spain, Italy, Malta.

Region 3: South-East Europe:
Greece, Austria, Romania, Bulgaria, Cyprus.

Region 4: North-East Europe:
Finland, Poland, Estonia, Latvia, Lithuania, Slovenia, The Czech Republic, Slovakia, Hungary.

For these four regions we extracted the gross human consumption (kilogram of food categories) of main food items per capita, between 1991-2009 from Eurostat. The data was calculated first as a simple average of the reported consumption in the subsequent years for each country. In order to calculate EU-27 average and region-specific averages, a population-weighted average procedure was applied (while carefully excluding from the calculation the countries where no consumption of a given food item was reported). Table 3 gives an overview of the current diet bundle in the EU-27. As we aim for consistency we used the information provided by Eurostat which is limited to certain number of categories (see Table 2). This implies that we lack detailed information on fish and seafood and any information on fresh drinks.

Table 2 **Lists of food items in Eurostat**

Cereals (excluding rice) (kg/head)	There are sub-groups: Wheat, Maize, and Barley
Rice-Total (kg/head)	
Beef (kg/head)	
Pork (kg/head)	
Sheep & Goat (kg/head)	
Poultry (kg/head)	
Equidae (kg/head)	
Drinking milk (kg/head)	
Cheese & Butter (kg/head)	There are two sub-groups: Cheese & Butter
Eggs (kg/head)	
Veg. fats & Oils (kg/head)	
Fresh fruits (kg/head)	There are sub-groups: Apples, Pears, Peaches (fresh and processed), Grapes Citrus fruits and Oranges
Nuts & Dried fruits	There are sub-groups: Nuts, Dried pulses and Dried fruits
Vegetables (excluding potatoes) (kg/head)	There are sub-groups: Cauliflowers and Tomatoes (fresh and processed)
Potatoes (kg/head)	
Sugar (equiv. white sugar) (kg/head)	
Honey (kg/head)	
Wine (lt/head)	

The information in Table 3 reflects the 'gross apparent human consumption' which is a proxy indicator for the availability of food to the consumer at the retailer shops but not of the actual consumption by households. A suggestion to tackle this issue while calculating actual consumption in kcal is to subtract 10% of the total number of kilo calories per day to reflect food wastes[1]. In this way we reduce the overestimation of the food bundle.

Table 3 **The current diet bundle per region within the EU-27 plus Turkey and Croatia in kilograms**

(Kg/head)/Region	European Union (27 countries)	Region 1 North-West Europe	Region 2 South-West Europe	Region 3 South-East Europe	Region 4 North-East Europe
Cereals (including bread)	120.96	107.00	124.67	145.52	140.16
Rice	4.88	4.18	6.37	4.10	3.31
Beef	17.30	17.23	22.25	12.88	7.48
Pork	41.06	41.76	41.79	33.50	42.63
Sheep & Goat	3.52	2.88	3.93	4.70	0.84
Poultry	21.04	19.53	23.17	19.68	20.60
Equidae	0.82	1.11	0.78	0.33	0.00
Milk	83.82	92.96	78.55	77.20	77.81
Cheese & Butter	20.17	20.09	21.73	19.68	17.03
Eggs	13.11	12.33	14.15	11.96	9.30
Veg. fats & Oils	17.86	18.51	20.52	18.31	7.30
Fresh fruits	95.43	74.92	141.47	70.63	55.72

1 There are several studies which suggest different proportion of the food is actually wasted. Most of the studies indicated more than 10%. However, this exercise aims at giving an indication of the different behavioural options/measures in the food consumptions.

(Kg/head)/Region	European Union (27 countries)	Region 1 North-West Europe	Region 2 South-West Europe	Region 3 South-East Europe	Region 4 North-East Europe
Nuts & Dried fruits	8.04	7.35	11.25	7.85	3.93
Vegetable (no potatoes)	133.45	85.37	173.63	164.95	63.09
Potatoes	79.00	87.01	61.75	76.04	107.30
Sugar	33.65	36.40	30.83	29.36	36.16
Honey	0.68	0.77	0.51	1.47	0.52
Wine (lt/head)	28.95	19.75	48.76	22.34	9.48

Source: LEI and CE Delft calculation using Eurostat statistics on the Gross human apparent consumption of main food items per capita, between 1991-2009.

From the number of consumed kilograms we then calculated the number of consumed calories, using the calories calculator of the Dutch Institute of Public Health and the Dutch Center of Nutrition (Voedingcentrum information). The number of calories was based on average values of comparable item see Table 4 of the calories per item as suggested by the Dutch Institute of Public Health and the Dutch Center of Nutrition (Voedingscentrum information).

Table 4 Kilocalories per kilogram

Cereals (including bread)	3,650
Rice	1,100
Meat (approximate average factor for all types)	2,510
Milk	470
Cheese & Butter	4,500
Eggs	1,360
Veg. fats & Oils	8,950
Fresh fruits	550
Nuts & Dried fruits	4,620
Vegetable (no potatoes)	320
Potatoes	1,010
Sugar	2,000
Honey	3,210
Wine (lt/head)	7,450

Source: Dutch Institute of Public Health and the Dutch Center of Nutrition (Voedingcentrum information).

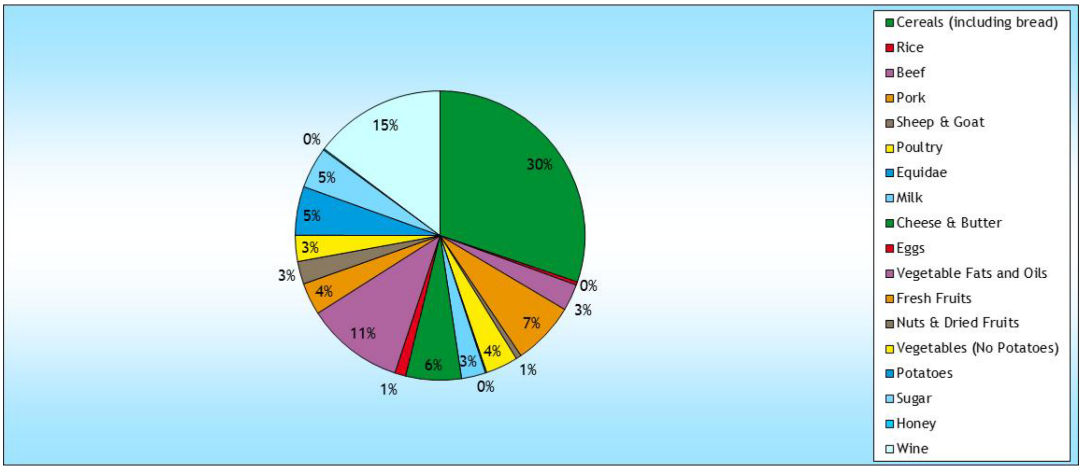
The average number of calories per head per year per product are provided in Table 5.

Table 5 **Average number of calories per head per year per product for the four regions (-10%)**

(Kg/head)/Region	European Union (27 countries)	Region 1 North-West Europe	Region 2 South-West Europe	Region 3 South-East Europe	Region 4 North-East Europe
Cereals (including bread)	397,338.87	351,507.73	409,536.42	478,027.32	460,426.17
Rice	4,830.49	4,142.89	6,302.58	4,057.76	3,281.17
Beef	39,090.82	38,911.77	50,271.41	29,103.63	16,900.16
Pork	92,753.35	94,346.96	94,403.41	75,677.07	96,293.79
Sheep & Goat	7,961.53	6,505.55	8,879.89	10,617.47	1,901.49
Poultry	47,540.63	44,112.01	52,336.10	44,464.93	46,538.09
Equidae	1,849.68	2,518.14	1,766.79	753.00	0.00
Milk	35,455.74	39,321.99	33,226.80	32,657.64	32,911.78
Cheese & Butter	81,676.59	81,357.18	88,011.35	79,713.88	68,985.95
Eggs	16,043.73	15,097.77	17,325.44	14,638.68	11,383.20
Veg. fats & Oils	143,888.68	149,082.31	165,255.48	147,520.41	58,810.20
Fresh fruits	47,239.60	37,083.74	70,026.70	34,962.82	27,580.57
Nuts & Dried fruits	33,450.98	30,572.39	46,791.70	32,644.31	16,340.54
Vegetable (no potatoes)	38,432.50	24,587.98	50,006.00	47,505.50	18,169.34
Potatoes	71,811.13	79,089.26	56,127.62	69,121.43	97,531.69
Sugar	60,568.91	65,522.33	55,490.42	52,846.22	65,088.32
Honey	1,978.49	2,226.21	1,487.72	4,236.05	1,516.48
Wine (lt/head)	194,117.89	132,439.89	326,929.97	149,786.60	63,551.47
Total kcal per capita per year	1,316,029.62	1,198,426.11	1,534,175.80	1,308,334.71	1,087,210.42
Total kcal per capita per day	3,605.56	3,283.36	4,203.22	3,584.48	2,978.66

Using these numbers, we can show the relative proportions of product categories in the EU-27 diet. Figure 3 gives an illustration of the present diet and the amount of calories within EU-27.

Figure 3 **The distribution of calories per category of food (head/year) for the EU-27 - current diet**



To be able to estimate the development of these diets under BAU assumptions and under the assumptions of the three behavioural changes over time , we used a simplified approach assuming that the present composition of diet per capita remains unchanged over time and that changes over time are hence based on population changes. For the latter, we used growth projections for the four regions' population. These figures were obtained from Eurostat (see Table 6). Population changes focused on growth projection in a region and not on GDP per capita. GDP is often considered an indicator of a country's standard of living; GDP per capita is not a measure of personal income or purchase behaviour and therefore of less interest in this approach.

Table 6 **The growth projection of the EU population per region**

Population projection	2010	2020	2030	2050
European Union (27 countries)	501,103,425	513,837,632	519,942,079	515,303,488
Region 1: North-West Europe:	191,070,539	196,841,474	200,893,790	201,894,915
Region 2: South-West Europe:	182,094,101	18,9671,287	194,259,721	197,376,714
Region 3: South-East Europe:	49,509,451	49,255,243	48,434,950	45,896,879
Region 4: North-East Europe:	78,429,334	78,069,628	76,353,618	70,134,980

Eurostat: EUROPOP2008 - Convergence scenario, national level.

Behavioural change 1: Vegetarian diet

For Behavioural change 1 the modelled change in dietary choices is to stop all meat consumption, fish or seafood consumption.
For our calculations, we assume that total calorie intake remains unchanged. Therefore, calorie intake from other food categories is increased. Since research amongst vegetarians indeed shows that vegetarians have diets that are comparable to the diets of non-vegetarians, only higher in grains, legumes and vegetables (Haddad and Tanzman, 2003), we made the assumption that the reduction in meat consumption would be offset (in terms of calories) by increased consumption of cereals (which reflects grains and legumes) and vegetables. We made the assumption that consumption of cereals and vegetables would all increase in such a way that their proportion relative to each other would stay at the same level.
The number of calories from all other categories (including dairy products and eggs) stays at the same level as in the current level shown in Table 4 and illustrated in Figure 3.

Table 7 The number of calories per diet categories in the vegetarian behavioural change

(Kcal/head)/Region	European Union (27 countries)	Region 1 North-West Europe	Region 2 South-West Europe	Region 3 South-East Europe	Region 4 North-East Europe
Cereals (including bread)	569,848.89	525,716.28	594,597.35	624,124.55	615,923.46
Rice	4,830.49	4,142.89	6,302.58	4,057.76	3,281.17
Beef	0.00	0.00	0.00	0.00	0.00
Pork	0.00	0.00	0.00	0.00	0.00
Sheep & Goat	0.00	0.00	0.00	0.00	0.00
Poultry	0.00	0.00	0.00	0.00	0.00
Equidae	0.00	0.00	0.00	0.00	0.00
Milk	35,455.74	3,9321.99	33,226.80	32,657.64	32,911.78
Cheese & Butter	81,676.59	8,1357.18	88,011.35	79,713.88	68,985.95
Eggs	16,043.73	15,097.77	17,325.44	14,638.68	11,383.20
Veg. fats & Oils	143,888.68	149,082.31	165,255.48	147,520.41	58,810.20
Fresh fruits	47,239.60	37,083.74	70,026.70	34,962.82	27,580.57
Nuts & Dried fruits	33,450.98	30,572.39	46,791.70	32,644.31	16,340.54
Vegetable (no potatoes)	55,118.49	36,773.87	72,602.66	62,024.38	24,305.58
Potatoes	71,811.13	79,089.26	56,127.62	69,121.43	97,531.69
Sugar	60,568.91	65,522.33	55,490.42	52,846.22	65,088.32
Honey	1,978.49	2,226.21	1,487.72	4,236.05	1,516.48
Wine (lt/head)	194,117.89	132,439.89	326,929.97	149,786.60	63,551.47
Total kcal per capita per year	1,316,029.62	1,198,426.11	1,534,175.80	1,308,334.71	1,087,210.42
Total kcal per capita per day	3,605.56	3,283.36	4,203.22	3,584.48	2,978.66

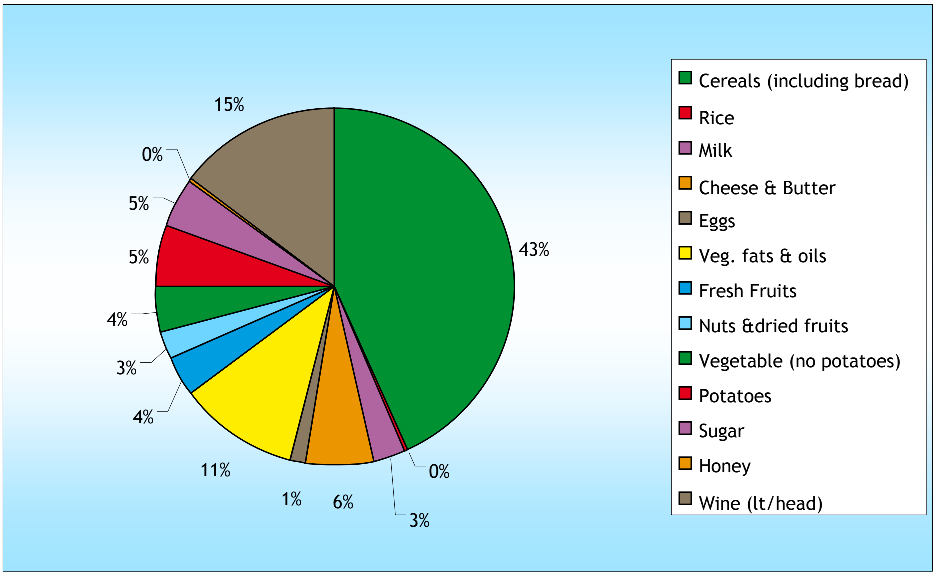
Table 8 provides the apparent gross consumption in terms of kilograms.

Table 8 The total kilograms of the vegetarian diet of Behavioural change 1

(Kg/head)/Region	European Union (27 countries)	Region 1 North-West Europe	Region 2 South-West Europe	Region 3 South-East Europe	Region 4 North-East Europe
Cereals (including bread)	173.47	160.04	181.00	189.99	187.50
Rice	4.88	4.18	6.37	4.10	3.31
Beef	0.00	0.00	0.00	0.00	0.00
Pork	0.00	0.00	0.00	0.00	0.00
Sheep & Goat	0.00	0.00	0.00	0.00	0.00
Poultry	0.00	0.00	0.00	0.00	0.00
Equidae	0.00	0.00	0.00	0.00	0.00
Milk	83.82	92.96	78.55	77.20	77.81
Cheese & Butter	20.17	20.09	21.73	19.68	17.03
Eggs	13.11	12.33	14.15	11.96	9.30
Veg. fats & Oils	17.86	18.51	20.52	18.31	7.30
Fresh fruits	95.43	74.92	141.47	70.63	55.72
Nuts & Dried fruits	8.04	7.35	11.25	7.85	3.93
Vegetable (no potatoes)	191.38	127.69	252.09	215.36	84.39
Potatoes	79.00	87.01	61.75	76.04	107.30
Sugar	33.65	36.40	30.83	29.36	36.16
Honey	0.68	0.77	0.51	1.47	0.52
Wine (lt/head)	28.95	19.75	48.76	22.34	9.48

Figure 4 gives an overview of the vegetarian diet, in which the calories from meat are replaced by the same number of calories from substitute product categories cereals and vegetables.

Figure 4 The distribution of calories from the EU - Diet 1 (vegetarian)



Behavioural change 2: Reduced intake of animal protein (meat, dairy, eggs)

In this behavioural change, European citizens diminish their consumption of animal protein. Reduction of animal protein intake is a promising behavioural change because the production of animal protein in general, that is including not only meat but also dairy products and eggs, is responsible for a great deal of food-related GHG emissions, and is often also linked. However, because meat and dairy are an essential part of most European meals, it is not realistic to expect European citizens to greatly reduce their intake of animal proteins. Currently, it is estimated that in the Netherlands only 16,000 people, or 0.1% of the Dutch population, follow a vegan diet (NVV, 2011), a percentage that is likely to be much lower in more carnivorous culinary cultures such as Spain and Portugal. Behavioural change 2 therefore does not assume a completely vegan diet. Rather, it is assumed that people forego animal protein for one day per week. Going without animal protein for one day per week is considered feasible given the importance of animal protein in Europeans' current diets. Assuming that most Europeans currently eat animal proteins every day, this comes down to a reduction of animal protein consumption with 14% (one seventh) We assume that the total number of calories per capita per year remains the same. As with the vegetarian diet (see above), we made the assumption that the reduction in animal protein (meat, dairy products and eggs) consumption would be offset (in terms of calories) by increased consumption of cereals (which includes grain and legumes) and vegetables. This is in line with recommendations for vegan diets (American Heart Association, 2011). We also made the assumption that consumption of cereals and vegetables would all increase in such a way that their proportion relative to each other would stay at the same level.

Table 9 provides the distribution of calories across food categories.

Table 9 The distribution of calories under Behavioural change 2: one day less animal protein intake

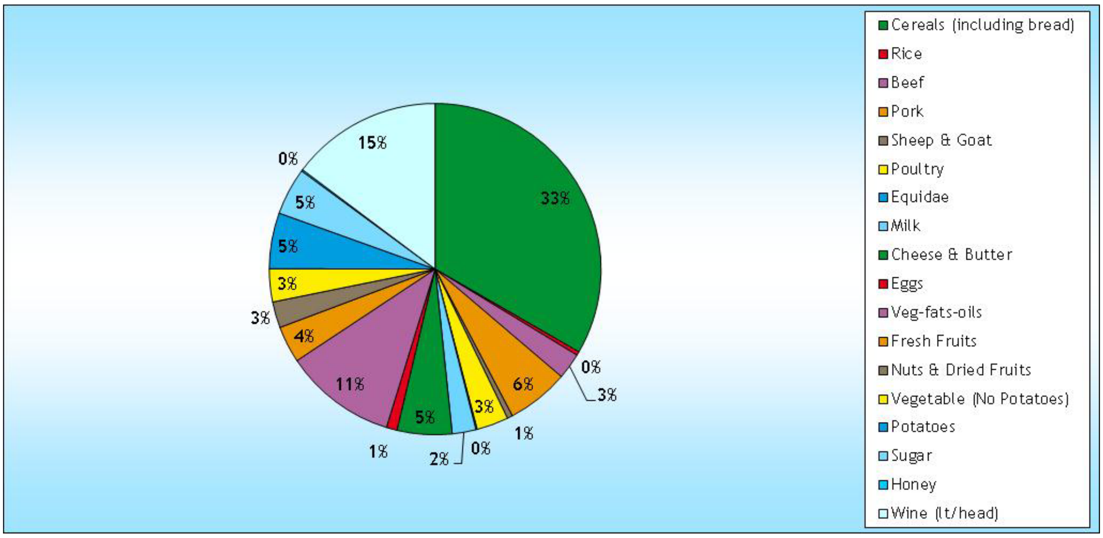
(Kcal/head)/Region	European Union (27 countries)	Region 1 North-West Europe	Region 2 South-West Europe	Region 3 South-East Europe	Region 4 North-East Europe
Cereals (including bread)	438,490.57	393662.97	452,732.92	500,559.49	497,453.04
Rice	4,830.49	4,142.89	6,302.58	4,057.76	3,281.17
Beef	33,618.11	33,464.12	43,233.41	25,029.12	14,534.13
Pork	79,767.88	81,138.39	81,186.94	65,082.28	82,812.66
Sheep & Goat	6,846.92	5,594.77	7,636.70	9,131.02	1,635.28
Poultry	40,884.94	37,936.33	45,009.05	38,239.84	40,022.76
Equidae	1,590.73	2,165.60	1,519.44	647.58	0.00
Milk	30,491.94	33,816.91	28,575.05	28,085.57	28,304.13
Cheese & Butter	70,241.87	69,967.18	75,689.76	68,553.93	59,327.92
Eggs	13,797.61	12,984.08	14,899.88	28,085.57	9,789.55
Veg. fats & Oils	143,888.68	149,082.31	165,255.48	147,520.41	58,810.20
Fresh fruits	47,239.60	37,083.74	70,026.70	34,962.82	27,580.57
Nuts & Dried fruits	33,450.98	30,572.39	46,791.70	32,644.31	16,340.54
Vegetable (no potatoes)	42,412.89	27,536.74	55,280.46	49,744.70	19,630.50
Potatoes	71,811.13	79,089.26	56,127.62	69,121.43	97,531.69
Sugar	60,568.91	65,522.33	55,490.42	52,846.22	65,088.32
Honey	1,978.49	2,226.21	1,487.72	4,236.05	1,516.48
Wine (lt/head)	194,117.89	132,439.89	326,929.97	149,786.60	63,551.47
Total kcal per capita per year	1,316,029.62	1,198,426.11	1,534,175.80	1,308,334.71	1,087,210.42
Total kcal per capita per day	3,605.56	3,283.36	4,203.22	3,584.48	2,978.66

Table 10 The distribution of kilograms under Behavioural change 2: one day less animal protein intake

(Kg/head)/Region	European Union (27 countries)	Region 1 North-West Europe	Region 2 South-West Europe	Region 3 South-East Europe	Region 4 North-East Europe
Cereals (including bread)	133.48	119.84	137.82	152.38	151.43
Rice	4.88	4.18	6.37	4.10	3.31
Beef	14.88	14.81	19.14	11.08	6.43
Pork	35.31	35.92	35.94	28.81	36.66
Sheep & Goat	3.03	2.48	3.38	4.04	0.72
Poultry	18.10	16.79	19.92	16.93	17.72
Equidae	0.70	0.96	0.67	0.29	0.00
Milk	72.08	79.95	67.55	66.40	66.91
Cheese & Butter	17.34	17.28	18.69	16.93	14.65
Eggs	11.27	10.61	12.17	22.95	8.00
Veg. fats & Oils	17.86	18.51	20.52	18.31	7.30
Fresh fruits	95.43	74.92	141.47	70.63	55.72
Nuts & Dried fruits	8.04	7.35	11.25	7.85	3.93
Vegetable (no potatoes)	147.27	95.61	191.95	172.72	68.16
Potatoes	79.00	87.01	61.75	76.04	107.30
Sugar	33.65	36.40	30.83	29.36	36.16
Honey	0.68	0.77	0.51	1.47	0.52
Wine (lt/head)	28.95	19.75	48.76	22.34	9.48

Figure 5 illustrates the reduction of the share of animal protein consumption by 14% and this reduction is replaced to an equal amount of calories from substitute products.

Figure 5 The distribution of calories from the EU per year - Diet 2 (one day no animal protein)



Behavioural change 3: Healthy eating

In Behavioural change 3 the diet of the EU-27+ population is changed to be in accordance with the most important recommendations for healthy eating: reducing daily intake to 2,500 kilocalories and eating 500 grams of fruits and vegetables, which in turn limits the total fat to 30% of caloric intake and saturated fatty acids to 10%, reducing sugar intake to 10% of total caloric intake and limiting salt intake to a maximum of 5 grams per day (WHO/FAO, 2002). According to WHO/FAO, reducing intake to 2,500 calories is advisable because the balance between calories consumed and calories burned is the central most important predictor of obesity and obesity-related diseases. Eating sufficient fruit and vegetable is also an important way of protecting the individual against cardiovascular diseases.

We have modelled the behavioural dietary changes that are directly related to the food categories used and the nutritional value. Reduced fat, sugar and salt intake could not be modelled because they don't translate directly to specific products.
Hence by using the 2,500 calories limitation combined with the reduction of other dietary categories given the priority to fruit and vegetables categories the caloric intake of fat, salt and sugar was limited as well.
The behavioural change is modelled by first increasing the consumption of fruit and vegetables to 500 grams (250 grams each for the categories fruits and 250 gram of vegtables (without potatoes)) and subsequently reducing the other dietary categories proportionally to achieve the total caloric intake.
This is illustrated in Table 11.

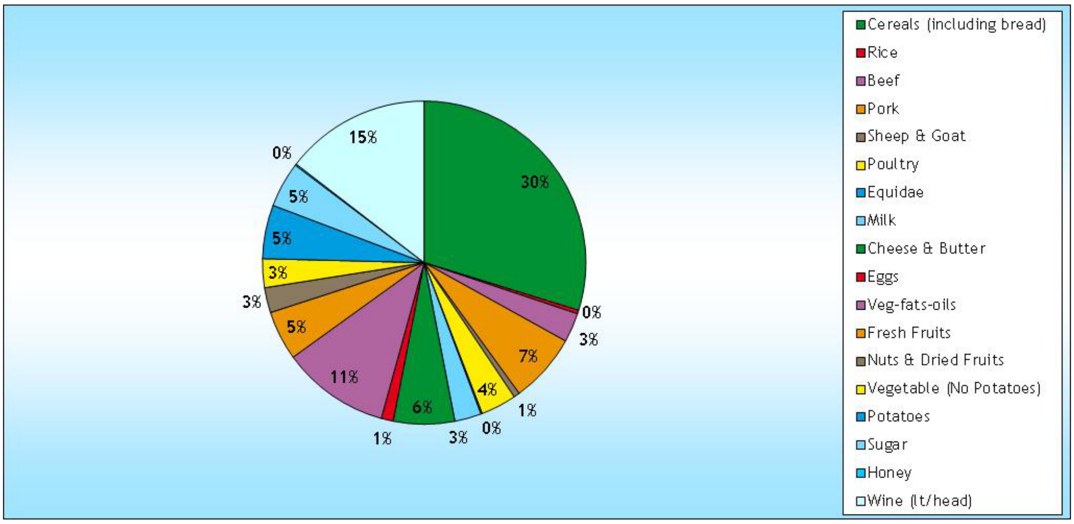
Table 11 The division of calories among the food items given that total calories per day is 2,500 and that 250 grams of fruits and 250 gram of vegetables (without potatoes)

(Kcal/head)/Region	European Union (27 countries)	Region 1 North-West Europe	Region 2 South-West Europe	Region 3 South-East Europe	Region 4 North-East Europe
Cereals (including bread)	271,614.02	260,070.27	243,568.79	327,968.43	371,825.92
Rice	3,302.04	3,065.20	3,748.41	2,783.98	2,649.77
Beef	26,721.81	28,789.68	29,898.55	19,967.63	13,648.04
Pork	63,404.59	69,804.55	56,145.74	51,921.07	77,763.89
Sheep & Goat	5,442.37	4,813.27	5,281.25	7,284.51	1,535.58
Poultry	32,497.96	32,637.18	31,126.51	30,506.82	37,582.72
Equidae	1,264.41	1,863.10	1,050.78	516.62	0.00
Milk	24,236.94	29,093.18	19,761.39	22,405.99	26,578.53
Cheese & Butter	55,832.72	60,193.79	52,344.11	54,690.67	55,710.92
Eggs	10,967.22	11,170.40	10,304.18	10,043.41	9,192.72
Veg. fats & Oils	98,359.83	110,301.63	98,284.49	101,211.86	47,493.29
Fresh fruits	45,168.75	45,168.75	45,168.75	45,168.75	45,168.75
Nuts & Dried fruits	22,866.52	22,619.62	27,829.02	22,396.84	13,196.11
Vegetable (no potatoes)	26,280.00	26,280.00	26,280.00	26,280.00	26,280.00
Potatoes	49,088.85	58,515.82	33,381.49	47,423.33	78,763.57
Sugar	41,403.87	48,478.05	33,002.52	36,257.12	52,563.31
Honey	1,352.47	1,647.11	884.81	2,906.30	1,224.67
Wine (lt/head)	132,695.65	97,988.39	194,439.21	102,766.67	51,322.20
Total per year	912,500.00	912,500.00	912,500.00	912,500.00	912,500.00
Total per day	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00

Table 12 The distribution of kilograms under Behavioural change 3: Healthy diet (250 gram of fruit and 250 gram of vegetables per day while reducing the total calories to 2,500)

(Kg/head)/Region	European Union (27 countries)	Region 1 North-West Europe	Region 2 South-West Europe	Region 3 South-East Europe	Region 4 North-East Europe
Cereals (including bread)	82.68	79.17	74.15	99.84	113.19
Rice	3.34	3.10	3.79	2.81	2.68
Beef	11.83	12.74	13.24	8.84	6.04
Pork	28.07	30.90	24.85	22.98	34.42
Sheep & Goat	2.41	2.13	2.34	3.22	0.68
Poultry	14.39	14.45	13.78	13.50	16.64
Equidae	0.56	0.82	0.47	0.23	0.00
Milk	57.30	68.78	46.72	52.97	62.83
Cheese & Butter	13.79	14.86	12.92	13.50	13.76
Eggs	8.96	9.13	8.42	8.21	7.51
Veg. fats & Oils	12.21	13.69	12.20	12.57	5.90
Fresh fruits	91.25	91.25	91.25	91.25	91.25
Nuts & Dried fruits	5.50	5.44	6.69	5.39	3.17
Vegetable (no potatoes)	91.25	91.25	91.25	91.25	91.25
Potatoes	54.00	64.37	36.72	52.17	86.65
Sugar	23.00	26.93	18.33	20.14	29.20
Honey	0.47	0.57	0.31	1.01	0.42
Wine (lt/head)	19.79	14.61	29.00	15.33	7.65

Figure 6 **The distribution of the calories from the EU per year – Diet 3 (healthy diet with reduced calories)**



3.2 Assessment of GHG abatement potential

Different diets identified in the previous section imply various levels of GHG emissions. The aim of this section is to show the differences between the BAU diet and the three alternative diets assumed for the EU-27 population in terms of GHG emissions. These differences are shown in total, according to the four identified regions but also per product category. Emissions are calculated first per capita and then as an absolute value, taking into account population numbers according to the different regions. Prediction of population growth can be used for future forecasts, provided that the level of per capita consumption and GHG emissions per kg of product is assumed to be constant over time.

Emissions calculated here refer to the category of gross apparent human consumption as reported by Eurostat, which is 10% higher than actual consumption - thus food losses (food produced but not consumed) are taken into account in our emissions estimates.

3.3 GHG emissions according to different diets

GHG emissions related to different diets have been calculated based on LCA factors from two studies:

1. Where available, the factors from the recent JRC study (Leip et al., 2010) have been used, coming from CAPRI model. This study focuses however only on meat and dairy products. The LCA factors which are relevant for our analysis include the following: beef, cow milk, pork, sheep and goat, poultry and eggs. These factors are provided in terms of kilograms of CO_2 eq. per kilogram of product. Land use and land use change and forestry (LULUCF) estimates are given separately; in our analysis we are using the factors not including LULUCF for consistency with other factors where such numbers were not available[2].

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2 Besides, LULUCF factor estimates are still controversial and difficult to estimate, which is reflected in large intervals for these values as calculated in the JRC study (the values in parentheses in Table 13 refer to different scenarios for calculating the LULUCF values).

2. For food items where the JRC factors were not available, the study of Blonk et al. (2008) has been used as a source. The study of Blonk was made for the Netherlands and the factors refer to the products available on a Dutch market; here we make an assumption that the same average factors can be used for products available at the EU-27 market as a whole. These factors do not include LULUCF estimates.

A comparison of factors which are available in both studies shows that they are very close to each other – see Table 13 below (for comparison refer to the numbers excluding LULUCF).

Table 13 Comparison of GHG factors from the study of Blonk et al. (for the Netherlands) and from the JRC study (for the EU-27)

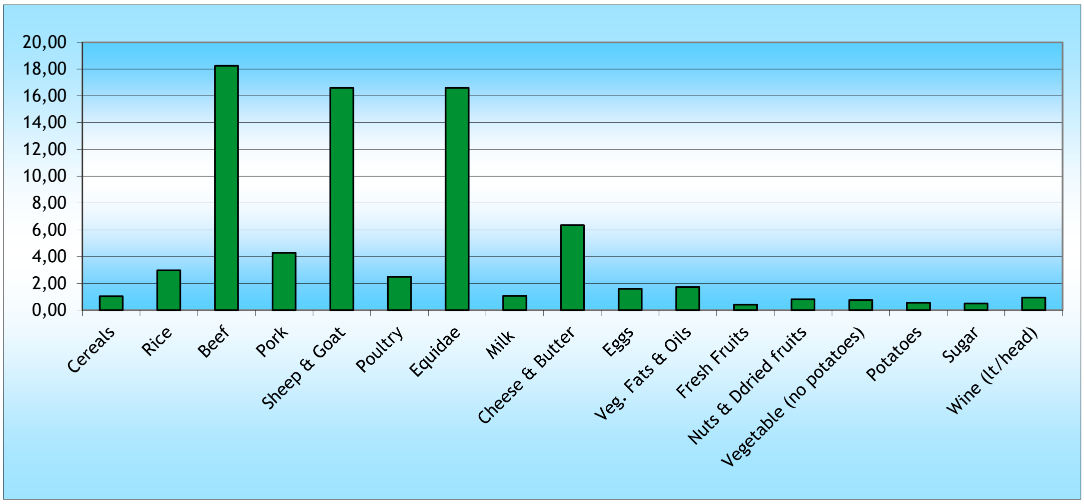
Category	JRC factors (CAPRI)			Blonk (without LULUCF)	
	Total	LULUCF	CAPRI without LULUCF		Comments
Beef	22.2	3.96 (2.86-9.41)	18.24	37.15	Irish
				16.2	Dutch
Milk	1.4	0.33 (0.26-0.64)	1.07	1.13	
Pork	7.5	3.1 (2.5-5.8)	4.4	4.29	
Sheep & goat	20.3	3.7 (2.2-11.7)	16.6	15.73	
Poultry	4.9	2.4 (2.1-4.2)	2.5	2.83	
Eggs	2.9	1.33 (1.26-1.69)	1.6	1.74	

Source: Leip et al. (2010) and Blonk et al. (2008).

Special attention should be given to beef because these factors are the highest and besides they seem to be highly dependent on the place of origin of beef. Leip et al. (2010) calculate a factor for beef reflecting an average estimate for the EU-27. The same study shows also diversification of beef factors, with the range from 14.2 CO_2 eq. in Austria to 44.1 CO_2 eq. in Cyprus. Blonk et al. (2008) also estimate a few factors depending on the origin of meat. The average factor for the EU based on the JRC study is similar to the factor based on Blonk et al. (2008) related to Dutch beef (see Table 13).

It should be noted that the categories of products identified in our project for defining various diets did not match exactly the categories based on chain analysis. Therefore, some assumptions had to be made. For some categories, an average value was taken as an estimate (like e.g. for cereals including bread where the factors for bread were given in the study of Blonk et al. separate from the factors for cereals). For meat of goats and sheep, one LCA factor is proposed. Consumption of goat and sheep was only provided in the Eurostat statistics as an aggregate and we assumed a 50/50 division between consumption of these two types of meat. No factor for emissions related to the category of meat equidae (horse family) could be found, therefore we assumed that this factor is equal to the factor provided for goat and sheep. No factor for honey was found so we decided to skip this whole category from further estimates; the impact of this category would in any case be very low because of low consumption.
The factors per kilogram of various food products are presented in Figure 7. Detailed values are to be found in Annex A.

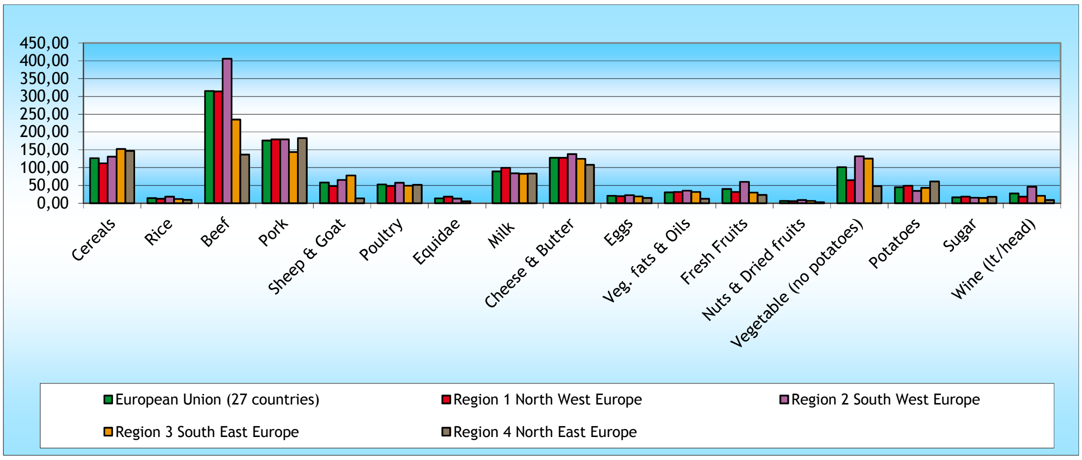
Figure 7 Climate emission impact of various food products, kg of CO_2 eq. per kg of product



The highest factors relate to meat; beef, with the factor of over 18 kg of CO_2 eq. per kg of product is characterised with the highest score regarding climate burden among all meat types and also as compared to other food products. This is related to a relatively long production chain of beef (growing feed products, rearing the animals and finally processing and transport). GHG emission factors for meat in general relate to three main phases in the chain of production: methane and nitrous oxide generated during the process of digestion, energy generated mostly during feed production and the use of pesticides.

GHG factors from LCA analysis of various products have been used to calculate climate change impact of different diets identified before, i.e. BAU, vegetarian diet (Diet 1), diet with reduced meat consumptions (one day per week with no meat – Diet 2) and diet with reduced calories intake, 250 grams fruit and 250 grams vegetables a day (Diet 3). Detailed results of these calculations are presented in Annex A. Below we present comparison of the regions regarding GHG emissions in BAU scenario (Figure 8).

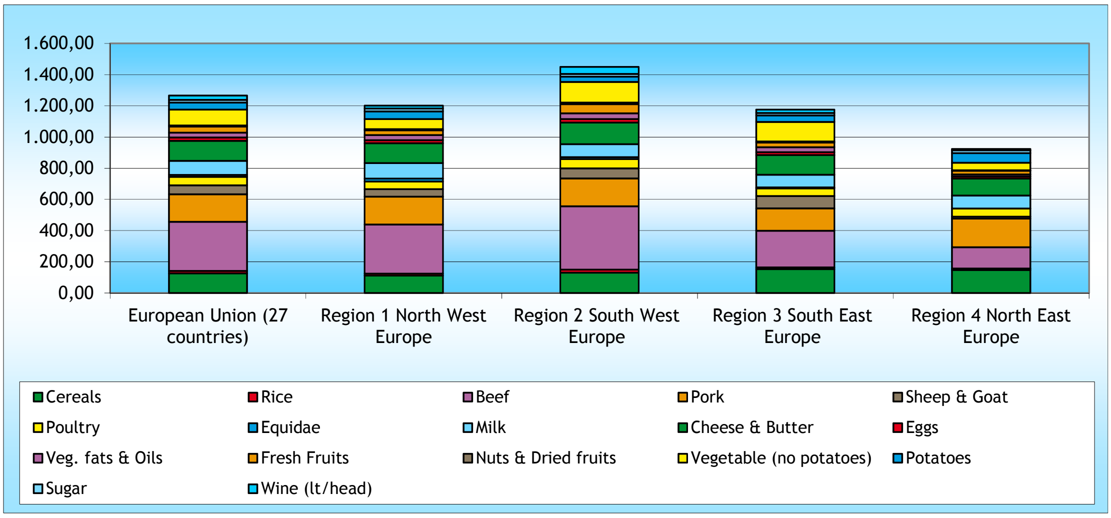
Figure 8 GHG emissions per capita in kg of CO_2 eq. per year according to BAU scenario



It can be seen that the largest climate impact results from meat and especially beef. Other animal-based products such as dairy also imply relatively high emissions. The graph shows also regional differences. Regions differ especially in meat consumption which translates into CO_2 emission differences. In Region 2 the highest amounts of beef are consumed while in Region 4 consumption of beef is the lowest while consumption of pork – the highest.

Figure 9 below shows regional differences in climate burden according to BAU scenario expressed in kilograms of CO_2 eq.

Figure 9 Annual GHG emissions per capita in regions, kilograms of CO_2 eq. per capita per year

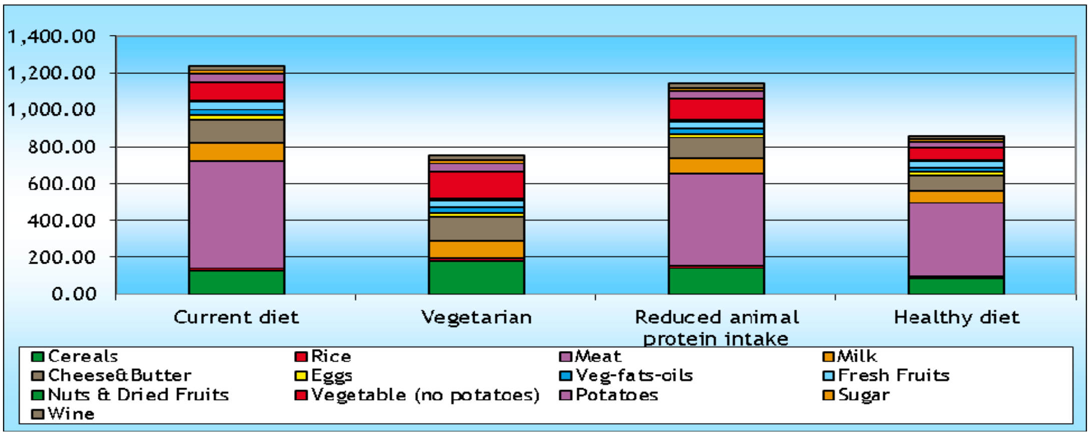


Looking at regional differences it can be seen that the diet pattern of the Region 4 (North-East Europe) implies the lowest climate burden (slightly below 1 tonne of CO_2 eq. per capita), followed by Region 3 (South-East Europe). The highest burden per capita (over 1,400 kg per capita per year) is estimated for Region 2 (South-West Europe). These differences are mostly due to the differences in consumption of beef per capita. The lowest amount of beef per capita is consumed in Region 4 and the highest amount – in Region 2. Detailed estimates of the amounts of food products per capita in different diets and regions are given in Annex A.

3.4 Changes in GHG emissions related to diet shifts

The goal of this section is to show climate change impact of a shift from BAU scenario to different diets identified earlier. Relative differences between the regions stay more or less the same in different diets thus for illustrative comparison of different diets, only EU-average is taken into account (see Figure 10).

Figure 10 GHG emissions per capita per year in different diets, kg of CO_2 eq., EU average



In this figure, the category of meat is not divided into subcategories to make the picture more readable. It is obvious that the category of meat is the most significant source of GHG emissions. **Shifting to Diet 1 (vegetarian) would imply cutting GHG emissions per capita on average in the EU by about 40% as compared to BAU** (from approximately 1,272 kg of CO_2 eq. per year per capita to about 755 kg). Detailed estimates can be accessed in Annex A.

In the next step, the estimated emissions per capita have been multiplied by the current population numbers according to the regions (see Table 14).

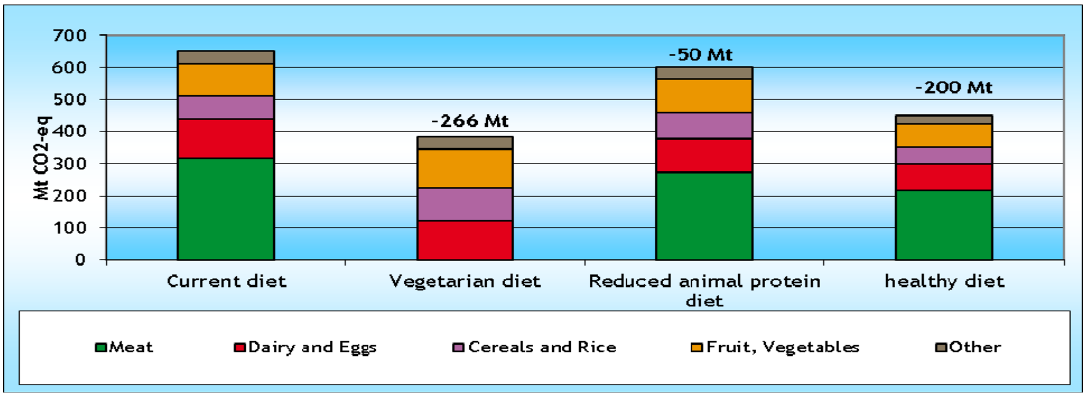
Table 14 Projected population in the EU and the regions in 2020

	2020
EU total	514,365,687
Region 1	196,381,342
Region 2	189,801,188
Region 3	49,130,141
Region 4	79,053,016

Source: Eurostat statistics, EUROPOP2010.

Figure 11 below shows the estimates of total climate impact of BAU and different diets in the EU-27 and the regions in megatonnes of CO_2 equivalent per year.

Figure 11 Total climate impact in BAU and different diets, Mt of CO_2 eq. per year, 2020



Total food-related emissions in BAU scenario are estimated at the level of about 634 Mt per year for the whole EU-27. With all EU citizens shifting to a vegetarian diet these emissions would drop by about 40%, to the level of approximately 375 Mt per year. Shifting to Diet 2 would imply a drop in GHG to the level of approximately 585 Mt per year (8% drop as compared to BAU). Shifting to Diet 3 would result in an estimated amount of approximately 440 Mt of CO_2 eq. annually, which is about 30% less than in BAU.

The next step in our analysis is distinguishing GHG emissions generated outside the EU-27. Two factors leading to GHG emissions originating outside the EU have been identified:

1. Import of food products from outside the EU-27. In order to assess the share of GHG emissions related to food products imported from non-EU countries, Eurostat trade statistics have been used. In some cases (e.g. rice, meat) the amounts imported from non-EU countries seem to be quite low as compared to consumption, thus some underestimate could have taken place and therefore the numbers should be treated as a conservative estimate. Table 15 presents the estimated share of imports from outside the EU in total annual consumption of various food items.

Table 15 Share of non-EU imports in gross total consumption in the EU (2010)

Food item	Share of non-EU imports in gross consumption
Cereals (including bread)	16.10%
Rice	51.67%
Beef	2.29%
Pork	0.92%
Sheep & Goat	7.20%
Poultry	1.53%
Equidae	7.42%
Milk	0.02%
Cheese & Butter	1.18%
Eggs	0.10%
Veg. fats & Oils	24.13%
Fresh fruits	23.41%
Nuts & Dried fruits	23.41%
Vegetable (no potatoes)	5.67%
Potatoes	1.00%
Sugar	27.71%
Wine (lt/head)	9.13%

Source: Eurostat statistics.

2. For animal-derived products (meat and dairy products), the production chain was explored to find out that in some cases quite a significant share of GHG emissions was related to energy use. The energy use is mainly related to production of feed. Feed for animal breeding within the EU often comes from outside the EU. Trying to estimate precisely the share of animal feed coming from outside of the EU for various types of animals exceeds the scope of the project; here we make an assumption based on rough calculations of Blonk et al. (2008) that 50% of energy generated within the production chain of animal-derived food and 50% of energy related to the use of pesticides (also used for animal feed) come from outside the EU. Thus we take a simplified assumption that 50% of feed for all animal types is imported from outside the EU. Table 16 presents the estimated share of climate impact in terms of CO_2 eq. emissions related to non-EU emissions due to feed production.

Table 16 **Non-EU emissions related to production of feed in the category of meat and dairy products produced within the EU**

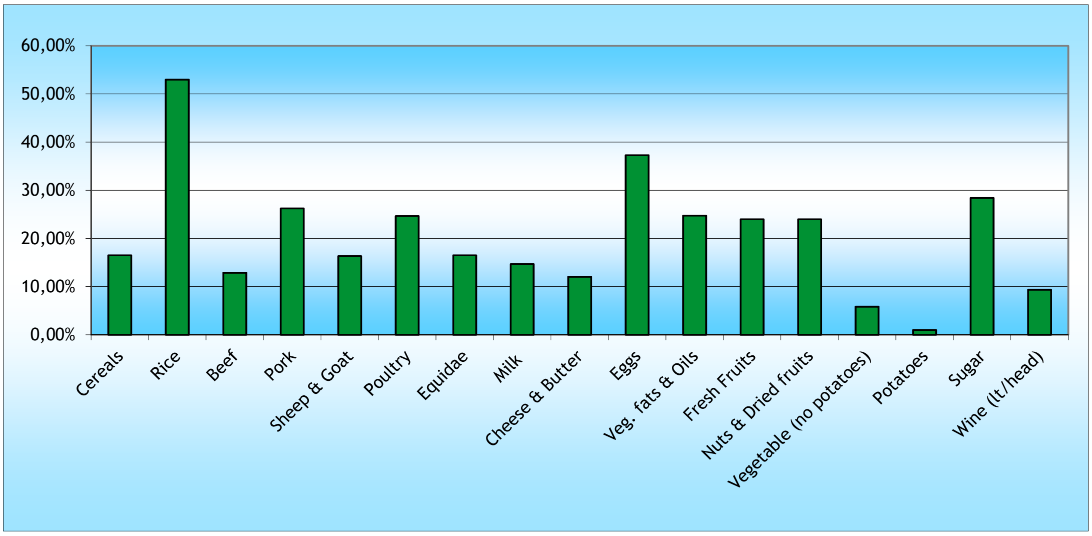
Food products	Estimated share of non-EU emissions
Beef	11%
Pork	26%
Sheep & Goats	10%
Poultry	23%
Equidae	10%
Milk	15%
Cheese & Butter	11%
Eggs	37%

Source: Own calculations based on Blonk et al. (2008).

While accounting for non-EU emissions we are using the same climate impact factors based on Leip et al. (2010) and Blonk et al. (2008) irrespective of the actual place of production which is not analysed further. This means that we take a simplified assumption that the climate impact of food products produced outside the EU is the same as the impact related to the same products produced within the EU (or in case of the factors based on Blonk et al. (2008), in the Netherlands). Climate impacts of production outside the EU can in some cases be higher (e.g. in case of Brazilian beef – much more extensive production methods, grazing on free pastures leads to much higher emissions of methane than in Europe) and in some cases lower (e.g. in developing countries production of food may imply less energy input and more labour input); on average the errors related to using the same factors for the part of production originating from within and from outside the EU should not be significant.

Altogether, according to our calculations, direct GHG emissions generated outside the EU (including non-EU imports and non-EU feed for animals bred within the EU) constitute only about 15% of total emissions related to food consumption in the EU. Figure 12 below presents the estimates of non-EU emissions according to different food categories. It should be kept in mind that the emission estimates do not include emissions related to land use, land use changes and forestry.

Figure 12 **Percentages of non-EU emissions in the BAU scenario**



Source: Own calculations based on Eurostat statistics.

Among the different products, rice has the highest percentage of non-EU emissions (over 50%), which is not surprising knowing that most rice consumed within the EU is imported. Potatoes, vegetables and wine are characterised with relatively low share of GHG emissions originating from outside of the EU (below 10%).

Figure 13, Figure 14 and Figure 15 below show the absolute drop in Mt of GHG emissions resulting from the three modelled diet shifts while distinguishing the EU and non-EU generated emissions.

Figure 13 Absolute drop in GHG emissions due to diet shift from BAU to Diet 1 (vegetarian), distinguishing EU and non-EU emissions (Mt per year, 2020)

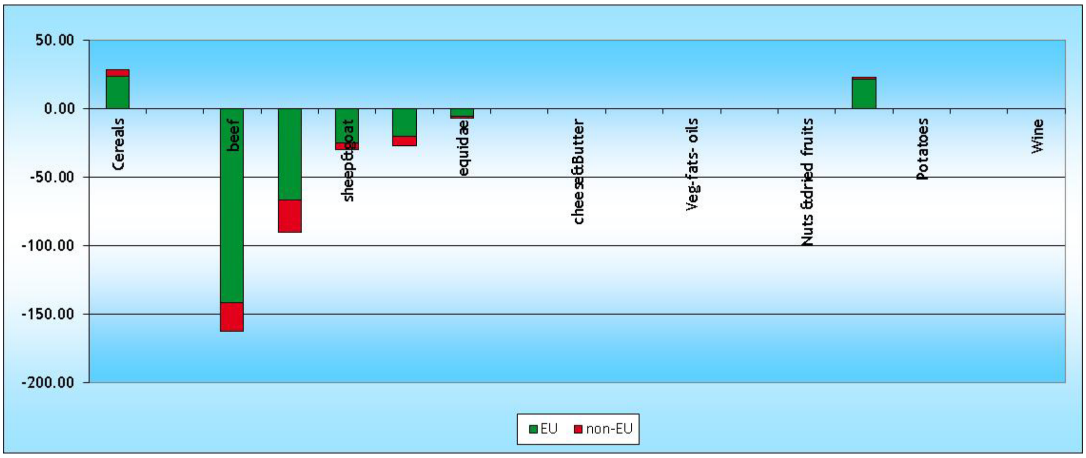


Figure 14 Absolute drop in GHG emissions due to diet shift from BAU to Diet 2 (one day a week without animal protein), distinguishing EU and non-EU emissions (Mt per year, 2020)

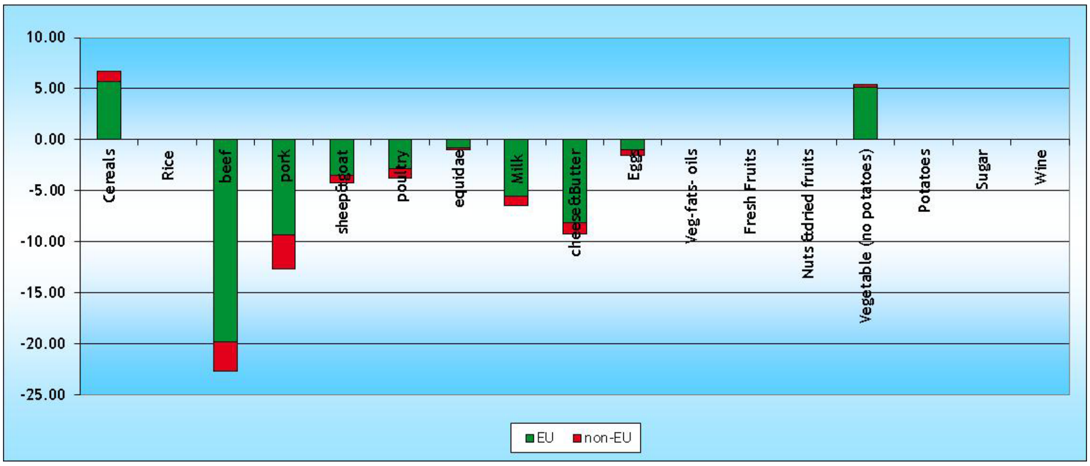


Figure 15 Absolute drop in GHG emissions due to diet shift from BAU to Diet 3 (reduced calories and 500 g of fruit and vegetables a day, 2020)

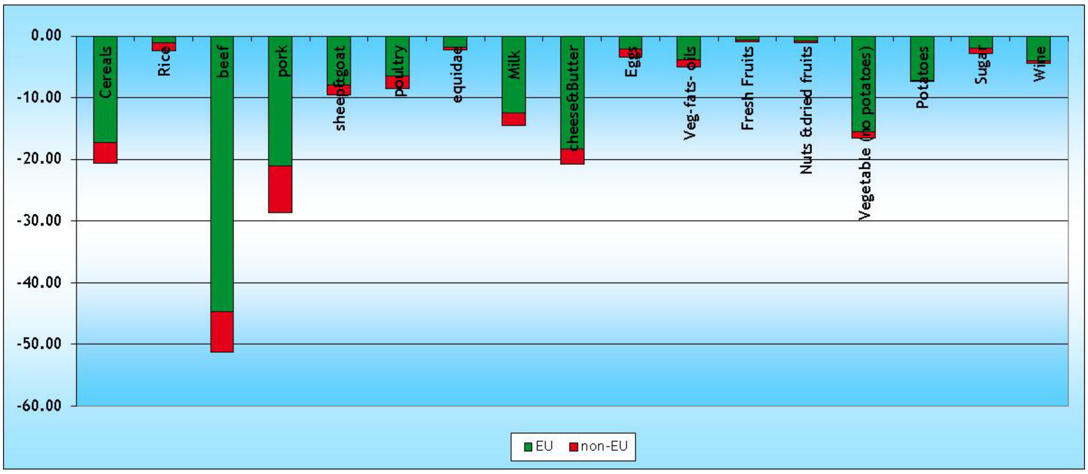
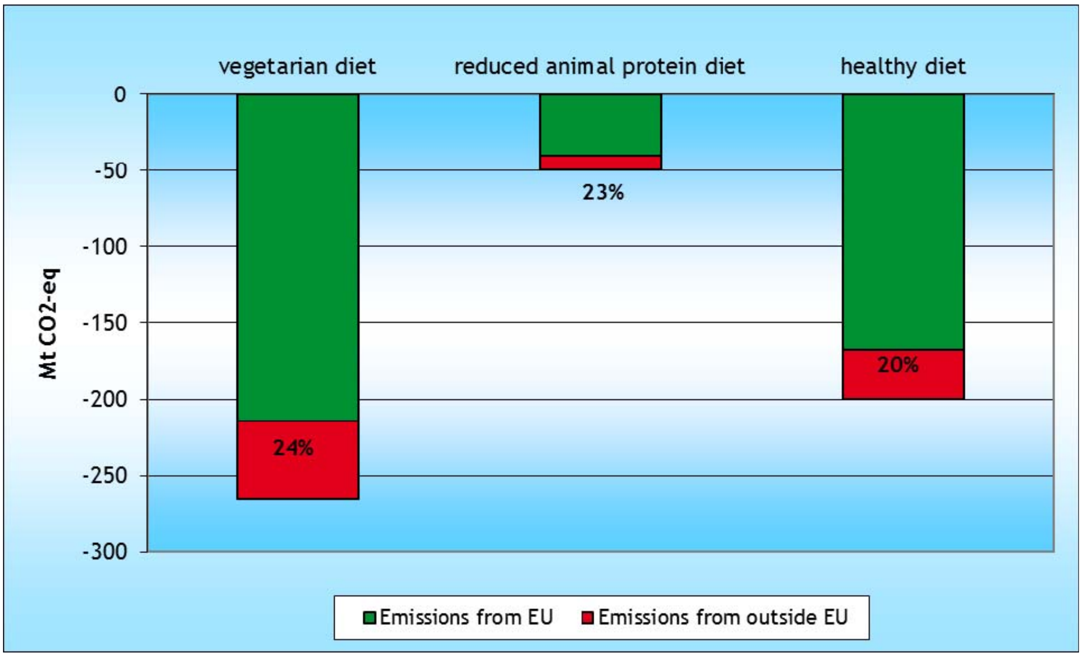


Figure 16 shows the total drop in GHG emissions due to diet shifts, with division into EU and non-EU emissions.

Figure 16 Total maximum realistic abatement potential of diet shifts, with division into EU and non-EU emissions, 2020



With the shift from BAU to Diet 1, where in total about 260 Mt of CO_2 eq. would be reduced per year, approximately 24% of the reduced GHGs would have other than the EU origin. Shift to Diet 2 implies about 48 Mt of CO_2 eq. annual reduction, with about 23% of reduction being non-EU emissions. Shift to Diet 3 would result in about 195 Mt reduction of GHGs annually, with almost 20% originating from outside the EU. Detailed numbers underlying the figures can be found in Annex A.

3.5 Indirect effects

3.5.1 Indirect effects of a vegetarian diet and a reduced animal protein intake diet on land use emissions

Diets with less meat result in a lower demand for grassland and a higher demand for cropland. As a result, grassland may be converted to cropland resulting in a change in land use emissions. The extent to which this happens depends on two counteracting factors:

1. Since cattle and poultry consume plants, a reduction in meat demand results in a reduction of demand for crops, resulting in a lower demand for cropland and possibly a conversion from cropland to other uses.
2. Since humans following a vegetarian or reduced meat diet eat relatively more crops, the demand for crops increases, resulting in higher demand for cropland and possibly a conversion from grassland to cropland.

Most animals raised for meat that are consumed in Europe and around the World[3] consume animal feed (made from crops) to meet the majority of their calorific requirements[4]. Large scale adoption of vegetarian or near-vegetarian diets would merely result in a shift in the types of crops that are produced. For example, a reduction in the production of large scale soy, corn and grain production would take place, and would be partially replaced with a greater variety of crops, such as a greater proportion of vegetables and fruit. The degree to which this would take place would be related to the types of meat that are replaced or continue to be eaten and the types of crops grown to meet nutritional and consumer demand.

Whether a conversion from grassland to cropland would release CO_2 in the atmosphere depends on the type of grasslands that are used for grazing. In Europe, most cattle, for example, do not get the majority of their calorie intake from grazing, but rather from cattle feed (which was grown on croplands). In Brazil, where cattle do actually get all of their calories from grazing, the grasslands have come into existence often as a result of rainforest deforestation. In this case the large release of CO_2 from deforestation is allocated between cattle grazing activities and the production of soy crops (which are in large part used to produce animal feed). Argentine beef cattle, while also relying entirely on grazing as feed, has a much lower carbon footprint than Brazilian beef cattle. This is as a result of the type of land used for grazing, which in Argentina are in the Pampas, a low lying plains region. Unlike the occupation of deforested areas, the occupation of natural plains land does not result in an inherent allocated release of carbon dioxide.

The amount of crops used for the purpose of feeding livestock vs. feeding people is dependent upon a few different factors:

- crops yields can differ wildly between different crop types, thus also varying the amount of land used;
- fertilizer application can differ between farms, crops and regions;
- calories per unit weight of crop (i.e. potatoes have far more calories per kg than a vegetable such as celery, which consists of a very high percentage of water);
- allocation of usable parts of the crop;

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3 Countries like China and India are both increasing their meat consumption and are increasingly shifting towards the American/Western model of agriculture which relies on large scale production of mono-crops in order to produce animal feed.

4 WUR, 2010 Kwantitatieve Informatie Veehouderij. Wageningen: Animal Sciences Group Wageningen UR (WUR, 2010).

– feed conversion rates vary per type of animal.

Any comparison would need to take place at a macro level, taking into consideration meat production as a whole, vs. a balanced vegetarian diet, including crops such as grains, legumes, nuts, vegetables and fruits. Several such macro-level studies have been conducted, which examine the relative efficiencies of various diets.

3.5.2 Relation between production and consumption

There are many possible points of intervention to reduce the indirect effects caused by the two different policy packages, ranging from shifts in consumption patterns, to adaptations of husbandry systems, raising crop yields to reduce the land area needed, and improved management to add more value towards animal products. For each indirect effect, multiple scenarios to reduce indirect effects could be formulated. In some cases these options are directly related to possible policy measures, such as raising minimum standards of space required per animal in husbandry systems. In other cases, such as those of consumption shifts and increases in crop yields, policy measures or interventions by other actors will be less directly connected to these physical options (Westhoek, H. et al. (2011), The Protein Puzzle, The Hague: PBL Netherlands Environmental Assessment Agency).

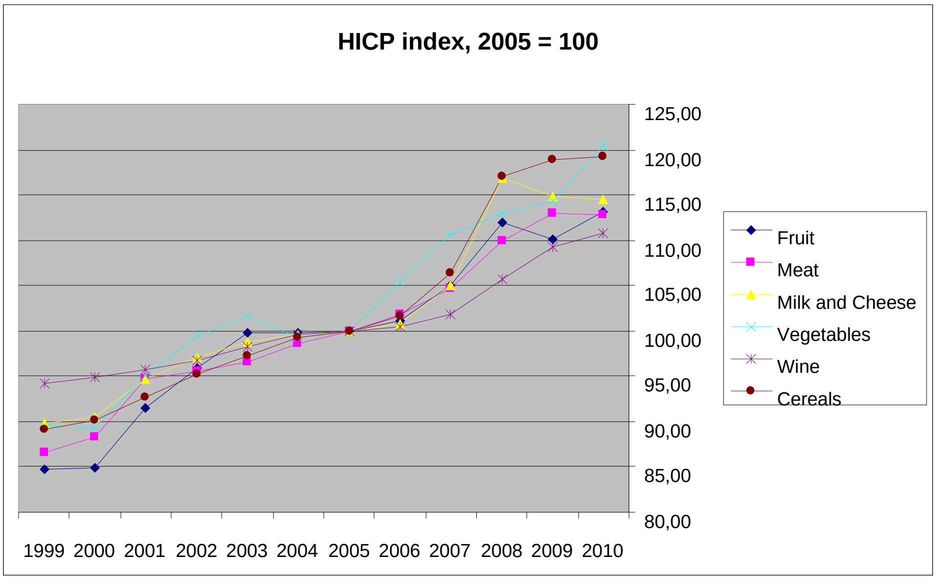
– Possibility 1: Reduction of consumption of meat leads to a shift in the diary production sector which could be corresponding with the demographic shift in Europe exposed in reduction of dairy farming. This is a structural change with a possible positive impact on the remaining dairy farmers in Europe.
– Possibility 2: Reduction of consumption of meat leads to an increase awareness for welfare and added value of meat products and therefore has an equal or positive effect on farmer income.
– Possibility 3: Reduction of consumption of meat lead to a shift in land use from grass to crop land and has a positive effect on GHG emission.
– Possibility 4: Reduction of meat consumption leads to more export of meat products outside the EU and less input of meat (beef) to the EU. This will also influence land use option outside the EU.

A number of possibilities for reducing certain indirect effects simultaneously lead to improvements for other issues, as well (synergy), but they may also lead to the aggravation of others (trade-offs). In many cases there are synergies, for example, because several problems have the same origin. Reduction in the demand for animal products, in particular, will benefit biodiversity and human health, as well as reduce nitrogen and greenhouse gas emissions. The same synergies occur in the case of increased feed efficiency. (Westhoek, H. et al. (2011), The Protein Puzzle, The Hague: PBL Netherlands Environmental Assessment Agency).

3.6 Costs of diet shifts

The costs related to diet shift are calculated on the basis of consumer expenditures and price indices data taken from Eurostat statistics. Price indices refer to the harmonised index of consumer prices (HICP) which is a standard inflation indicator for the whole EU area. The structure of consumer expenditures does not match exactly the food categories adopted in our analysis therefore some adjustments had to be made. Meat is presented as one category. The categories for which no specific data on consumer expenditures was available were bundled as one category (other) and the expenditures on this category were estimated as a difference between the mean expenditures on food in general and other categories. The most recent data for food expenditures were available for 2005 therefore price indices were used to update these expenditures to the level of 2010. Figure 17 shows the indices.

Figure 17 Price indices for food in EU-27



Source: Eurostat.

For some products, i.e. vegetable oils and sugar, no separate indices were available and in these cases the general index of price increase for food has been used (equal to 115.37 in 2010).

Table 17 presents the mean expenditures per capita in Euro[5] per year for various food products in EU-27, adjusted to the level of 2010 prices.

Table 17 Mean expenditures on various food product categories per year per capita in Euro 2010

Region	EU average
Cereals (including bread)	625.13
Meat	843.14
Milk , cheese and eggs	502.96
Veg. fats & Oils	117.68
Fresh fruits	259.14
Vegetables (no potatoes)	385.18
Sugar	211.13
Wine (lt/head)	137.29
Other (including rice, potatoes, nuts and honey)	247.35
Total	3,329.00

Source: Own calculations based on Eurostat statistics.

5 Eurostat reports the expenditures not in Euro but in PPS (purchasing power standard) however by definition for EU-27 as an aggregate PPS is equal to Euro (PPS = PPP * Euro; PPP for EU in Eurostat statistics is equal to 1).

Mean expenditure data divided by the estimated volumes of food purchased in various categories[6] was used to calculate an approximate price per kilogram of consumption for each of the categories. Please note that these are only fictitious numbers and cannot be really seen as prices per kilogram of a given product; they refer to mean values for all EU the countries.

Table 18 Mean expenditures per capita divided by the estimated volume of food purchased according to food categories ('prices' per kg)

Food categories	EU average
Cereals (including bread)	5.69
Meat	12.29
Milk, cheese and eggs	4.92
Veg. fats & Oils	12.01
Fresh fruits	7.21
Vegetables (no potatoes)	4.95
Sugar	6.48
Wine (lt/head)	7.52
Other (rice, butter, nuts, potatoes, and honey)	3.10

Source: Own calculations based on Eurostat statistics.

Having a proxy for food prices per kg, we have multiplied them by the amounts referring to the three alternative diets to come up with cost differences related to diet shifts. The cost differences are calculated only for the EU as an average because the expenditures per capita and price indices used in calculations are not differentiated according to the regions.

Cost differences related to diet shifts, in percentage of BAU costs according to food categories are presented in Table 19, Table 20 and Table 21. Positive numbers mean increase in costs and negative numbers indicate drop in costs.

Table 19 Cost differences resulting from diet shifts: Diet 1 as compared to BAU

Region	EU average	Region 1	Region 2	Region 3	Region 4
Cereals (including bread)	40%	44%	46%	37%	36%
Meat	-100%	-100%	-100%	-100%	-100%
Milk, cheese and eggs	0%	0%	0%	0%	0%
Veg. fats & Oils	0%	0%	0%	0%	0%
Fresh fruits	0%	0%	0%	0%	0%
Vegetables (no potatoes)	40%	44%	46%	37%	36%
Sugar	0%	0%	0%	0%	0%
Wine (lt/head)	0%	0%	0%	0%	0%
Other (rice, butter, nuts, potatoes, and honey)	0%	0%	0%	0%	0%
Total	**-13%**	**-13%**	**-12%**	**-12%**	**-15%**

6 The amounts purchased are calculated as gross human consumption thus including food waste (food purchased but not consumed).

Table 20 **Cost differences resulting from diet shifts: Diet 2 as compared to BAU**

Region	EU average	Region 1	Region 2	Region 3	Region 4
Cereals (including bread)	10%	11%	11%	9%	9%
Meat	-14%	-14%	-14%	-14%	-14%
Milk, cheese and eggs	-14%	-14%	-14%	-14%	-14%
Veg. fats & Oils	0%	0%	0%	0%	0%
Fresh fruits	0%	0%	0%	0%	0%
Vegetables (no potatoes)	10%	11%	11%	9%	9%
Sugar	0%	0%	0%	0%	0%
Wine (lt/head)	0%	0%	0%	0%	0%
Other (rice, butter, nuts, potatoes, and honey)	-1%	-1%	-1%	-1%	-1%
Total	**-3%**	**-3%**	**-2%**	**-2%**	**-3%**

Table 21 **Cost differences resulting from diet shifts: Diet 3 as compared to BAU**

Region	EU average	Region 1	Region 2	Region 3	Region 4
Cereals (including bread)	-23%	-26%	-25%	-21%	-22%
Meat	-24%	-26%	-25%	-21%	-23%
Milk, cheese and eggs	-23%	-26%	-25%	-20%	-22%
Veg. fats & Oils	-23%	-26%	-24%	-20%	-22%
Fresh fruits	154%	145%	125%	165%	189%
Vegetables (no potatoes)	17%	40%	-4%	-7%	73%
Sugar	-23%	-26%	-25%	-20%	-22%
Wine (lt/head)	-23%	-26%	-25%	-20%	-22%
Other (rice, butter, nuts, potatoes, and honey)	-23%	-26%	-25%	-20%	-22%
Total	**-5%**	**-6%**	**-9%**	**-4%**	**0,2%**

According to our estimates, the highest savings on consumer costs are achieved by switching to a vegetarian diet. These savings are estimated to be equal on average to 13% of total expenditures per capita on food in the BAU scenario. Meat is relatively expensive so giving it up completely results in considerable savings while increased costs related to purchases of cereals and vegetables do not compensate the drop in expenses related to meat. Switching to other types of diets implies less significant changes in costs. Switching to Diet 2 (one day without animal proteins a week) lowers the total costs on food by 3% on average in the EU as compared with the BAU. In the third option, where total amount of calories is lowered, the drop in costs is more significant than in the second option (5% on average in the EU). In this scenario the most significant differences between the regions can be observed, which is related mostly to different levels of consumption of vegetables observed in the BAU. In Region 4 (North-East Europe) the projected increase in consumption of fruit and vegetables is so high that the increased expenses on these categories outweigh the reduced expenses in other categories, resulting in slight increase of overall expenses on food.

It is possible that the lower costs of the changed diets has a rebound effect, i.e. people would spend more on the food products they continue to buy. We have not been able to quantify this effect. We do not have evidence that such a shift (e.g. from cheap cereals to more expensive cereals, or from cheap poultry to more expensive poultry) would have a significant impact on emissions, although this may merit further study.

4 Barriers, consumer segments and policy instruments

4.1 Introduction

The three selected behavioural change options in the Food domain are addressed in two groups in this chapter, based on the barriers and consumer segments. A vegetarian diet and a diet with reduced animal protein intake both have as the main objective a reduction of GHG emissions. Hence, they have similar barriers for similar consumer segments. A healthy diet has a different purpose, has different advantages and disadvantages for consumers and as a consequence different barriers.

This chapter will discuss vegetarian diet and reduced animal protein intake first, and a healthy diet second.

4.2 Vegetarian diet and reduced animal protein intake

Many consumers report positive feelings in relation to sustainable food, but there is a gap between what people think, feel and say on the one hand, and what they do on the other hand (Bellows et al., 2008; De Winter et al., 2009). The medias and the public's attention for sustainable food is growing, but various barriers can stand in the way of actual sustainable behaviour. In Task 3.1 we identify and evaluate the barriers to the selection of the behavioural mitigation changes outlined in WP 2.1, based on desk- and literature research and interviews with experts. We make a distinction between *individual (internal) barriers*, such as socio-psychological factors, physiological characteristics and demographic factors, and *societal (external) barriers*, such as infrastructural barriers, cultural barriers, economic barriers and institutional barriers. After identifying the relevant barriers, we will evaluate the impact of these barriers, ranking them for impact. Next, we will identify relevant segments of consumers that are particularly likely (or unlikely) to experience one or more of these barriers. Finally, we will assess the likely diffusion pattern of the behavioural change in light of the identified barriers.

4.2.1 Identifying and categorising barriers for behavioural change

Many consumers report positive feelings in relation to sustainable food (De Winter et al., 2009). Still, sustainability is far from the only thing on consumers' minds as they make trade-offs between the advantages and disadvantages of lifestyle and product choices. In everyday life, several barriers can stand in the way of adopting a sustainable diet. Since the behavioural changes needed for a vegetarian diet (Behavioural change 1) and for a reduced animal protein diet (Behavioural change 2) are very similar, we will identify the barriers for these behaviours below. After this we will identify the barriers for a healthy diet separately. With regards to following a vegetarian diet and a reduced animal protein diet, the following barriers can be identified.

Internal barriers

With regards to internal barriers, *socio-psychological factors* seem to be the most important barriers to adopting a vegetarian or a reduced animal protein diet. For instance, knowledge about the environmental effects of meat consumption may be limited. Research shows that consumers believe that the decreased use of packaging is the most important aspect of environmentally friendly food consumption, whereas lower meat consumption is seen to help the least (Lea and Worsley, 2007). Thus, although consumers in general have moderately positive attitudes towards sustainable food consumption, they have little knowledge as to what is sustainable and what is not. Also, consumers can sometimes be confused by the use of different terminologies, such as organic, green, natural or environmentally friendly (Bhaskaran, Polonsky, Cary and Fernandez, 2006; Hughner, McDonagh, Prothero, Shultz and Stanton, 2007).

Physiological characteristics and unconscious behaviour might also be important. In particular, habits are another factor that could form a major barrier for behaviour change (Verplanken and Aarts, 1999). Even when consumers have sufficient knowledge and are motivated to start a vegetarian or a reduced animal protein diet, it will be very difficult to change the existing habit. Research has shown that when habits are strong, the enactment of the behaviour is to a large extent automatic (Wood and Neal, 2007) and intentions are poor predictors of behaviour (De Bruijn et al., 2007).

With regards to *situational factors*, research shows that sustainable consumption is negatively associated with perceived time barriers (Tanner and Kast, 2003). Thus, adhering to a vegetarian diet may take time and effort. Possibly, deciding on alternative recipes and doing the groceries for vegetarian or reduced animal protein recipes takes more time than cooking 'regular' meat dishes.

With regards to *demographic factors*, these do not seem to be reliably associated with sustainable food choices (Tanner and Kast, 2003).

External barriers

With regards to the external barriers of adopting a vegetarian or reduced animal protein diet, *infrastructural barriers* do not seem to be of great importance in retail settings, since the products that are assumed to be used as substitution for meat (grains, legumes, vegetables) are readily available in the supermarket. However, in the food-service sector (restaurants, cafés, street vendors) the availability of substitution products may be a problem.

Cultural barriers may be of great importance, especially when it comes to eating meat. De Bakker and Dagevos (2010) point out that meat is a vital part of culinary cultures in Western Europe and that many people see meat as an essential part of the meal.

Since substitution product e.g. grains, legumes and vegetables are generally not more expensive than meat, there are currently no *economic barriers* for adhering to a vegetarian or reduced animal protein diet (see Section 3.6).

There are also no *institutional barriers* to vegetarian or reduced meat diets. Aspects of gender and socio-economic factors are addressed in demographic barriers as no main driver. Research shows that sustainable purchases are not significantly related to socioeconomic characteristics of the consumers (Tanner and Kast, 2003).

4.2.2 Evaluating the barriers

It seems that, for vegetarian and reduced animal protein diets, knowledge, habits and cultural barriers are the most important barriers. It is likely that, once knowledge levels, habits and culinary cultures have changed, situational and infrastructural substitution products for meat and animal protein products will become available in the food service sector and in meals and products that are ready-made and easy to produce. Situational and infrastructural barriers therefore seem less important than knowledge, habits and cultural barriers.

One important question is whether the barriers are equally important for a vegetarian diet and a reduced animal protein diet. Because changing to a vegetarian diet constitutes a big change as compared to most consumers' current diets, whereas reducing animal protein intake to six days a week constitutes a more limited change and essentially leaves the diet intact on six out of seven days. We assume that habits and cultural barriers are slightly more important for a vegetarian diet than for reducing animal protein intake.

Table 22 Ranking of the barriers based on their relative impact for vegetarian and reduced animal protein diet

Barrier		Importance for reduced animal protein diet	Importance for vegetarian diet
Internal	Knowledge	++	++
	Habits	++	+++
	Lack of time	0	0
External	Cultural barriers	++	+++
	Infrastructural barriers	0	0

4.2.3 Consumer segments and diffusion patterns

One dimension that can be used to construct segments of consumers is knowledge. Knowledge can be two folded: for instance objective knowledge (governmental information, result of research, etc.) and subjective knowledge (family, peer groups, etc.) The level of knowledge could be an indicator of behavioural changes and used to construct consumer segments. Better informed consumers may make better informed purchasing decisions (Poole and Baron, 1996).

Policy instruments should be targeted at specific segments of consumers. Educational communication, for instance, should only be targeted at those consumers that currently lack knowledge. Therefore, strongly related to consumer knowledge is the interest of product information. For example, providing nutritional information should make the positive or negative consequences of consuming a certain product more salient to people (Garg et al., 2007). Because people of lower socio-economic status (SES) often have more trouble receiving and accurately interpreting nutrition-related information (Kunst and Mackenbach, 1994), low SES groups may also constitute a relevant consumer segment. On the other hand, research shows that sustainable purchases are not significantly related to socio-economic characteristics of the consumers (Tanner and Kast, 2003), suggesting that this variable is not a good dimension for creating consumer segments.

Another dimension on which consumer segments can be based is current meat or animal protein consumption. A recent study in the Netherlands showed that there is a considerable group of people in the population who, while not adhering to a completely vegetarian diet, consciously try to limit their intake of meat (De Bakker and Dagevos, 2010). In this study, actual vegetarians comprised only 4% of the sample, while so-called ‘flexitarians’ (defined as eating meat on 6 days a week or less) comprised 70%. This figure is higher than the authors of this report would have estimated. De Bakker and Dagevos conclude that empowering and enabling flexitarian behaviour is more promising than aiming to promote a complete vegetarian diet. Although little is known about flexitarian behaviour in South, Central and Eastern Europe, it is probable that the number of people who limit meat intake there, like the number of vegetarians, is smaller than in Western Europe. Still, De Bakker and Dagevos’ (2010) argument that empowering reduced meat intake will be more effective than encouraging people to stop eating meat altogether may also be valid in South, Eastern and Central Europe.

4.2.4 Assessing diffusion patterns

As outlined above, knowledge, habits and cultural barriers are the most important factors that stand in the way of vegetarian or reduced animal protein diets. Knowledge is a factor that can be changed by concerted educational efforts (Rothschild, 1999). Although some groups in the population, most notably people with low education and low socio-economic status are difficult to reach with such interventions (Kunst and Mackenbach, 1994), knowledge levels in the population as a whole can be increased in a relatively short time. Targeting knowledge levels should therefore be a first step of behaviour change policy. However, once consumers’ knowledge about the environmental effects of animal proteins is increased, habits will make it very difficult for people to change their behaviour. Changing habits takes an integrated approach, in which ‘downstream’ interventions, such as education, are combined with ‘upstream’ interventions, such as changes in the context and the immediate consequences of behaviour (Verplanken and Wood, 2006). Upstream interventions in the case of animal protein consumption can for instance consist of economic incentives to purchase plant-based protein products. When, on the long run, knowledge about the environmental effects of animal proteins has increased and consumers have been able to change their habits, then slowly, culinary cultures in Europe may start to move in the direction of more plant-based protein consumption. This would be a final and decisive stimulant to further reduce the intake of animal proteins. Such a process may develop at a faster pace for the reducing animal protein diet than for the vegetarian diet, since habits and cultural barriers are stronger for a vegetarian diet than for a reduced animal protein diet.

4.2.5 Policy instruments

As in the previous section, we will discuss Behavioural change 1 and Behavioural change 2 together, because they entail very similar behavioural changes (eating less meat in Behavioural change 1 and eating less meat and other animal proteins in Behavioural change 2).

Identifying relevant policy instruments

As has been shown above, knowledge, habits and cultural factors are the most important barriers for a change to a vegetarian diet or a reduced animal protein diet. It is unlikely that these barriers can be overcome in the short term, but on the long term educational interventions and laws can slowly nudge people in the proposed direction. The first policy instrument we will investigate consists of providing information about the environmental and health benefits of a diet with lower meat/animal protein, making use of mass-media campaigns. The advantage of the mass media is that they can reach vast audiences directly. Campaigns promoting decreased meat/animal protein consumption can raise awareness of environmental issues and increase knowledge in a large part of the population. On the short term, this can address the knowledge barrier that was discussed in the previous section. On the long term, this can influence social norms and cultural practices, addressing the cultural barrier that we identified. The second policy instrument consists of regulation introducing mandatory nutrition labelling, containing GHG effects of all food products. This can also address the knowledge barrier and will make it more clear to consumers which products are environmentally friendly and which are not. If consumers, as well as private and public purchasers, are to take environmental criteria into consideration in their purchases, it is important that they can find easily understandable and credible criteria to enable them to distinguish the truly 'green' products. Labelling also requires functioning communications from manufacturing through trade to final consumers, and each party in this chain needs to see the benefits of participating (Heiskanen et al., 2009).

However, there is still the fact that food choices are in large part habitual. A first relevant policy instruments that addresses this consists of school-based intervention programs (Reinaerts et al., 2007). Habits develop early in life, and it is therefore important to help children develop healthy and sustainable habits at a young age. Another way in which habits can be targeted is by using 'upstream' interventions, such as changes in the context and the immediate consequences of behaviour (Verplanken and Wood, 2006). In the present study we will investigate the potential effectiveness of charging meat/animal protein consumption with consumption taxes.

Evaluating policy instruments

At present, there are no concerted policy efforts in the Western world in which sustainable food consumption behaviours are targeted, although examples to test possibilities are generated. In the EU project EUPOPP (www.eupopp.net) in public catering (schools, etc.) in Finland reduced consumption of meat as a way to reduce the climate and environmental load was introduced in the way of 'vegetarian day' in public caterings. One major conclusion was this intervention educates consumers on more environmentally sound foods in an effortless and effective way. At this moment in time, the mass-media campaigns, product labelling, school-based interventions and animal protein consumption taxes that we will assess in the present section are not implemented anywhere in the world, at least not on a grand scale. Also, no studies that we know of have investigated the effectiveness and cost-effectiveness of such policy instruments, making it difficult to estimate effectiveness and cost-effectiveness. However, in the domain of health-promotion, a wealth of studies exist that either empirically investigate the effectiveness of mass-media campaigns, food product labelling, school-based interventions or consumption taxes, or model these effects based on theoretically sound assumptions. We will therefore make use of the health-promotion literature to estimate the effectiveness and cost-effectiveness of the three policy instruments.

Step 1: Effectiveness

Mass-media campaigns. Mass-media campaigns are frequently used to promote a healthy lifestyle. One advantage of mass-media campaigns is that it is possible to reach a very large number of people (Cavill and Bauman, 2004; Flay and Burton, 1990; Marcus, Owen, Forsyth, Cavill and Fridinger, 1998). But what exactly is a mass-media campaign? In the present report we define mass-media campaigns as *the use of mass-media in a specific time period to raise awareness of a certain topic and so create the conditions for change* (see also Flora, Maibach and Maccoby, 1989). Research into the effectiveness of mass-media campaigns is confronted with the problem that such campaigns are often implemented nation-wide, making it impossible to compare the intervention group with a control group (Campbell et al., 2000). The best way to assess the effects of mass-media campaigns is a study making use of an *interrupted time series design*, in which at least two assessments are conducted prior to implementation of the campaign and two assessments after implementation of the campaign (ZonMw, 2000). This type of research is only rarely done. In general, such studies yield evidence that mass-media campaigns can change knowledge levels, attitudes and intentions (IJzer, Siero and Buunk, 1998; Wammes et al., 2005; Wammes et al., 2007). Actual effects on behaviour are also reported, but are usually quite small (ZonMw, 2000). For instance, based on previous research (Dixon et al., 1998; Forster et al., 1995; Craig et al., 2007) a recent OECD report (2010b) estimates that mass-media campaigns implemented nationwide in five OECD countries (Canada, England, Italy, Japan, Mexico) can increase fruit and vegetable consumption with 18 grams per day.

Food product labelling

Since the enactment of the 'Nutrition Labeling and Education Act' (NLEA) in the United States in 1990, pre-packaged food products are accompanied by detailed information on the nutritional value of the product in a so called *nutrition fact sheet*. Europe has also seen the enactment of regulation that increased the availability of nutritional information on food products significantly. Although this is currently not mandatory, food products labels can in theory also include information about GHG emissions associated with the production of the product. But is this likely to affect consumer choice? Only a few studies have investigated the effects of nutrition labels on actual consumer behaviour (see also Grunert and Wills, 2007; Teisl and Roe, 1998). The results of these studies suggest that the effects of labels on food products are inconsistent. Some studies find positive effects (Levy et al., 1985; Muller, 1984), other studies find no effects (Achabal et al., 1987) and yet others find different results of different product categories (Balasubramanian and Cole, 2002; Teisl and Levy, 1997). Overall, the effects of nutrition labelling on actual consumer behaviour appear to be small (Upham et al., 2011). The OECD (2010b) puts the effect of nutrition labelling on fruit and vegetable intake on increase of 10 grams per person per day. In France research is done on environmental labelling with 168 enterprises to test the communication, adoption and chain effect in order to apply this on a larger scale (BioIS, 2008).

School-based interventions

Because habits develop early in life, schools are good place to try to change eating habits (Reinaerts et al., 2007). School-based interventions can take the form of offering cheap healthy or sustainable foods in school cafeteria, (French, Story, Fulkerson and Hannan, 2004), increasing the availability of healthy or sustainable products (Osganian et al., 2003), educating parents about the importance of dietary choices (Hopper, Gruber, Munoz and Herb, 1992) or educating pupils themselves (Reinearts et al., 2007). Research shows that school-based intervention can successfully change food choices (De Bruijn et al. (2005). One particular study showed that a school-based intervention was successful in changing pupils' habits (Reinaerts et al., 2007). The OECD (2010b) estimates that such interventions are likely to increase fruit and vegetable consumption with 38 grams per day for each pupil that is exposed to the intervention.

Consumption taxes
Fiscal incentives can directly affect consumption behaviours, and therefore influence lifestyle choices (OECD, 2010b). Sales taxes, or value added taxes, are often applied at different rates to different types of food. Several studies suggest that sales taxes can have an impact on consumption of unhealthy foods (Powell and Chaloupka, 2009). In a recent study the OECD (2010b) modelled the effectiveness of a fiscal measure that both increases the price of foods with a high fat content by 10% and decreases the price of fruit and vegetables. The effects of the fiscal interventions were modelled based on some of the most conservative estimates of the price elasticity of demand for foods high in fat and for fruit and vegetables among nine studies that were reviewed by Hespel and Berthod-Wurmser (2008). Results of the modelling study showed that the fiscal measure would produce an increase in the intake of fruit and vegetables per day per person of between 4 and 11 grams, and a decrease in the proportion of total energy intake from fats by between 0.58 and 0.76%.

Side-effects
Research into the health effects of animal- and plant-based foods shows that, on the whole, diets that are rich in plant-based food are associated with a lower risk of cancer and cardiovascular disease than diets that are rich in animal-based foods (Nestle, 2002). One important side-effect of reducing animal-protein foods, such as meat, is that it leads to better overall consumer health.

Step 2: Cost-effectiveness
As mentioned above, no data is available on the effectiveness and cost-effectiveness of policy measures designed to induce consumers to choose sustainable food products. Thus, there is no literature that indicates the cost-effectiveness of our four policy measures in Euro per ton of GHG emissions. Based on the OECD report cited above (OECD, 2010b), however, we can indicate the cost-effectiveness of mass-media campaigns, food product labelling, school-based interventions and consumption taxes in Dollar per gram of increased fruit and vegetable consumption, which may serve as a useful proxy for the cost-effectiveness of these measures if they would be applied to sustainable consumption instead of healthy consumption. Table 23 shows the interventions' estimated effectiveness in increasing fruit and vegetable intake, the estimated costs of the interventions in US Dollar at purchasing power parity with 2005 as the base year, and the ratio of increased intake and costs. It appears that consumption taxes are by far the most cost-effective way to change consumers' food choice behaviour, followed by mass-media campaigns and food product labelling.

Table 23 Cost-effectiveness of the four policy instruments for vegetarian and reduced animal protein consumption

Policy measure	Effectiveness in increase of fruit and vegetable consumption per person (grams)	Costs per person exposed to the policy measure (USD PPP)	Ratio of increased consumption and costs (gram/USD PPP)
Mass-media campaigns	18	0.5-2	9-36
Food product labelling	10	0.33-1.1	9.1-30.3
School-based interventions	38	1-2	19-38
Consumption taxes	4-11	0.03-0.13	30.8-366.7

Step 3: Assessment of (cost-)effectiveness of policy combinations
Since environmentally friendly food choices are hindered by multiple barriers (lack of knowledge, cultural barriers, habits), the use of more than one policy instrument could be considered. In fact, Verplanken and Wood (2006) argue that it is unlikely that any single intervention will result in large changes in behaviour across a population. Instead, interventions employing a comprehensive approach, targeting several barriers towards behaviour change at the same time are most likely to be successful in improving the quality of people's diets. However, evidence of the combined effectiveness of multiple interventions targeting consumer behaviour implemented simultaneously is virtually non-existent (OECD, 2010b). It is therefore difficult to predict whether combinations of interventions would create synergies which would translate into an overall effect larger than the sum of individual intervention effects, or whether adding interventions to a prevention strategy would have decreasing incremental returns. However, the OECD (2010b) has used a micro-simulation model to assess at least some of the effects to be expected from combining multiple interventions into a prevention strategy which targets different population groups. The assumption made in this analysis was a conservative one, estimating that the overall effect of interventions is less than additive relative to the effects of individual interventions. A combination of five policy instruments was explored, including compulsory food labelling and

school-based interventions. The results of the analysis showed that health impacts were up to twice as large as those attributable to the single most effective intervention, while the cost-effectiveness profile of the multiple-intervention strategy is very similar to that of the single most effective intervention. The cost of delivering the package of interventions varied between 12 and 24 USD PPP per capita in the different countries.

4.3 Healthy diet

Below, we will address the barriers that stand in the way of adhering to a healthy diet and will discuss potential policy instruments that can be used to target these barriers. Because many of the barriers and policy instruments are the same or similar to the barriers and policy instruments discussed above in relation to Behavioural change 1 and 2, we will at times refer to this previous section to avoid repetition. With regards to following a healthy diet, the following barriers can be identified.

4.3.1 Identifying the barriers

Internal barriers
With regards to internal barriers, *socio-psychological factors* can form barriers to adopting a healthy diet. On the one hand, knowledge about the negative effects of unhealthy diets is well-spread in the Western world (French et al., 2001), on the other hand, however, consumers may have difficulties determining which specific products are healthy and which are not (Van Kleef et al., 2008). Adequate knowledge at the product level is limited.

Physiological characteristics and unconscious behaviour might also be important. In particular, habits are an another factor that could form a major barrier for behaviour change (Verplanken and Aarts, 1999). Even when consumers have sufficient knowledge and are motivated to start a healthy diet, it will be very difficult to change the existing habit. Research has shown that when habits are strong, the enactment of the behaviour is to a large extent

automatic (Wood and Neal, 2007) and intentions are poor predictors of behaviour (De Bruijn et al., 2007).
With regards to *situational factors*, availability of money might be a barrier to following a healthy diet. This is not primarily because a healthy diet is more expensive – as shown in Section 3.6 a healthy diet results in lower expenditures, mainly because less food is consumed – but because per calorie, healthy products (e.g. fruit and vegetables) are more expensive than energy-dense products. University of Washington researchers found when they compared the prices of 370 foods sold at supermarkets. Calorie for calorie, junk foods not only cost less than fruits and vegetables, but junk food prices also are less likely to rise as a result of inflation (Monsivais and Drewnowski, 2007).[7] Although fruits and vegetables are rich in nutrients, they also contain relatively few calories. Foods with high energy density, meaning they pack the most calories per gram, included candy, pastries, baked goods and snacks. The survey found that higher-calorie, energy-dense foods are the better bargain for cash-strapped shoppers. Energy-dense munchies cost on average $ 1.76 per 1,000 calories, compared with $ 18.16 per 1,000 calories for low-energy but nutritious foods. Also, consumers indicate that a high price can be a barrier to choose healthy products (Inglis et al., 2005, Waterlander, 2010).

With regards to *demographic factors*, research reliably shows that the diets of people with low socio-economic status are less healthy than the diets of those with high socio-economic status (Beydoun and Wang, 2008). Socio-economic status may thus be an important barrier to adhere to a healthy diet.

External barriers
With regards to the external barriers of adopting a healthy diet, *infra-structural barriers* may be of great importance. Although healthy products are readily available in the supermarket, many authors have stressed that because of the abundant availability of unhealthy products, many people live in an ‘obesogenic environment’ (Dagevos and Munnichs, 2007; Story et al., 2008). This is to say that the options to choose for any number of unhealthy products are very numerous, causing many consumers to take in more calories than the recommended 2,000 kilocalories for women and 2,500 kilocalories for men.

It is difficult to say whether cultural barriers are of great importance. In most European countries, knowledge about the negative effects of unhealthy diets is well-spread and social norms stress health and fitness to a great extent (French et al., 2001). On the other hand, as seen above in the section about meat consumption, in many countries traditions may stress culinary practices in which meat, dairy and other high-calorie products loom large (De Bakker and Dagevos, 2010). Thus, culture may have both positive and negative effects, as culinary tradition favour high-calorie meals and modern consumer culture favours health and fitness. As a result of these positive and negative effects culture may not be a driver of healthy food choices but may also not be a great barrier.

Since individual healthy food products are generally somewhat more expensive than unhealthy products (see above), there may also be *economic barriers* for adhering to a healthy diet.

There are currently no *institutional barriers* to healthy diets.

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7 Monsivais, P. and Drewnowski, A. 2007. The Rising Cost of Low-Energy-Density Foods. Journal of American Dietetic Association 107:2071-2076.

4.3.2 Evaluating the barriers

It seems that, for healthy diets, knowledge about the healthiness of specific products, habits, socio-economic status, the obesogenic environment and economic barriers conspire to make healthy choices very hard. All of these barriers are important, although one can argue that economic barriers are less important than the other barriers, because food products are mostly very price-inelastic (OECD, 2010b).

Table 24 Ranking of the barriers based on their relative impact for healthy consumption

Barrier		Importance
Internal	Knowledge	++
	Habits	++
	Socio-economic status	++
External	Infrastructural barriers (obesogenic environment)	++
	Economic barriers	+

4.3.3 Identifying segments of consumers and assessing diffusion patterns

One dimension that can be used to construct segments of consumers is knowledge. Knowledge can be two folded: for instance objective knowledge (governmental information, result of research, etc.) and subjective knowledge (family, peer groups, etc.) The level of knowledge could be an indicator of behavioural changes and used to construct consumer segments. Better informed consumers may make better informed purchasing decisions (Poole and Baron (1996).

Policy instruments should be targeted at specific segments of consumers. Educational communication, for instance, should only be targeted at those consumers that currently lack knowledge. Therefore, strongly related to consumer knowledge is the interest of product information. For example, providing nutritional information should make the positive or negative consequences of consuming a certain product more salient to people (Garg et al., 2007). Because people of lower socio-economic status (SES) often have more trouble receiving and accurately interpreting nutrition-related information (Kunst and Mackenbach, 1994), low SES groups may also constitute a relevant consumer segment. Research that shows that people with low SES have significantly poorer diets than people with high SES especially suggests that this variable is a good dimension for creating consumer segments.

Assessing diffusion patterns

As outlined above, there are many barriers that stand in the way of healthy diets. Because of this, most Europeans currently do not adhere to the recommendations for healthy diets (for instance, in the Netherlands, only 8% of young adults eat in accordance with dietary recommendations for fruit consumption). With regards to the knowledge barrier, mandatory labelling on food products (already growing in use) can help consumers decide which products are healthy and which are not. This way, knowledge about the healthfulness of specific products could spread in a couple of years. Economic barriers can also be targeted, for instance with consumption taxes. However, income inequalities are very persistent and recently growing in Western countries (Jonung and Kontulainen, 2007). The problem that people with low socio-economic status have poorer diets than people with high socio-economic status is thus very difficult to solve. Concerted policy instruments on income-inequality should be employed, the effects of which will only show after a long time. Likewise, changing the abundant availability of unhealthy foods in the food market today is something that is only feasible on the long term. Changing habits takes an integrated approach, in which 'downstream' interventions, such as education, are combined with 'upstream' interventions, such as changes in the context and the immediate consequences of behaviour (Verplanken and Wood, 2006). Upstream interventions in the case of healthy consumption can for instance consist of economic incentives to purchase healthy products. When, on the long run, knowledge about the healthfulness of specific products has increased, consumers have been able to change their habits, economic incentives have eliminated the current economic barriers towards food consumption and food producers and retailers have decreased the availability of unhealthy products, European may slowly start to move in the direction of more healthy consumption. However, as in the case of vegetarian and reduced animal protein diets, this is a process that would take a long time to conclude.

4.3.4 Policy instruments

As has been shown above, knowledge, habits, socio-economic status, infrastructural and economic factors are the most important barriers for a change to a healthy diet. It is unlikely that these barriers can be overcome in the short term, but on the long term educational interventions and laws can slowly nudge people in the proposed direction. The first policy instrument we will investigate consists of regulation introducing mandatory nutrition labelling, containing nutritional information of all food products. This can have several effects. First, it can address the knowledge barrier and will make it more clear to consumers which products are healthy and which are not. Second, it can affect the production of healthy foods, as food manufacturers prefer to produce products which will be allowed to be described as healthy, thus targeting the infrastructural barrier of the availability of unhealthy food products. However, there is still the fact that food choices are in large part habitual. A first relevant policy instruments that addresses this consists of school-based intervention programs (Reinaerts et al., 2007). Habits develop early in life, and it is therefore important to help children develop healthy habits at a young age. Another way in which habits can be targeted is by using 'upstream' interventions, such as changes in the context and the immediate consequences of behaviour (Verplanken and Wood, 2006). In the present study we will investigate the potential effectiveness of charging meat/animal protein consumption with consumption taxes. This instrument goes some way to also tackle the economic barriers to healthy consumption and the barrier that is posed by socio-economic status.

Evaluating policy instruments

Step 1: Effectiveness

Food product labelling

As mentioned above, the results of studies investigating the effects of food product labelling on consumer behaviour show inconsistent results (Achabal et al., 1987; Balasubramanian and Cole, 2002; Levy et al., 1985; Muller, 1984; Teisl and Levy, 1997) and it seems safe to say that the effect of food product labelling is significant but small (OECD, 2010b). However, besides influencing consumers' product choice, food product labelling can also have an effect on the decisions of food manufacturers and retailers. If the general healthfulness of food products is shown on the product or package, manufacturers prefer to develop healthy products over unhealthy products and retailers prefer to offer healthy products in their stores (Dagevos and Van Kleef, 2009). Thus, food product labelling can affect both consumers' food choices and the availability of healthy and unhealthy products, targeting the knowledge barrier as well as the infrastructural barrier.

School-based interventions.
Because habits develop early in life, schools are good place to try to change eating habits (Reinaerts et al., 2007). As mentioned above, school-based intervention can successfully change food choices (De Bruijn et al., (2005).

Consumption taxes
Fiscal incentives can directly affect consumption behaviours, and therefore influence lifestyle choices (OECD, 2010b). As mentioned above, several studies suggest that consumption taxes can have an impact on consumption of unhealthy foods (OECD, 2010b; Powell and Chaloupka, 2009). By using consumption taxes, governments can 1) change the immediate consequences of the behaviour and thereby make it easier for people to change their habits (Verplanken and Wood, 2006), targeting the habit barrier, and 2) make healthy products cheaper, targeting the economic barrier. Because consumption taxes are likely to affect people on low incomes more strongly than people on high incomes (OECD, 2010b), they can also go some way to 3) target the barrier of socio-economic status.
Denmark has introduced what's believed to be the world's first fat food tax, applying a surcharge to foods with more than 2.3 percent saturated fats, in an effort to combat obesity and heart disease. The new tax of 16 kroner ($ 2.90) per kilogram (2.2 pounds) of saturated fat in a product will be levied on foods like butter, milk, cheese, pizza, oils and meat.

Side-effects
The healthy diets discussed in the present section serve the primary function of limiting the GHG emissions that are associated with food production. However, they are also likely to lead to better overall consumer health.

Step 2: Cost-effectiveness
Based on the OECD report cited above (OECD, 2010b), we can indicate the cost-effectiveness of food product labelling, school-based interventions and consumption taxes in Dollar per gram of increased fruit and vegetable consumption. Table 25 shows the interventions' estimated effectiveness in increasing fruit and vegetable intake, the estimated costs of the interventions in US Dollar at purchasing power parity with 2005 as the base year, and the ratio of increased intake and costs. It appears that consumption taxes are by far the most cost-effective way to change consumers' food choice behaviour, followed by food product labelling.

Table 25 Cost-effectiveness of the four policy instruments for healthy consumption

Policy measure	Effectiveness in increase of fruit and vegetable consumption per person (grams)	Costs per person exposed to the policy measure (USD PPP)	Ratio of increased consumption and costs (gram/USD PPP)
Food product labelling	10	0.33-1.1	9.1-30.3
School-based interventions	38	1-2	19-38
Consumption taxes	4-11	0.03-0.13	30.8-366.7

Step 3: Assessment of (cost-)effectiveness of policy combinations
Since healthy food choices are hindered by multiple barriers (lack of knowledge, habits, socio-economic status, infrastructural barriers and economic barriers), the use of more than one policy instrument could be considered. In fact, Verplanken and Wood (2006) argue that it is unlikely that any single intervention will result in large changes in behaviour across a population. Instead, interventions employing a comprehensive approach, targeting several barriers towards behaviour change at the same time are most likely to be successful in improving the quality of people's diets. As mentioned above, evidence of the combined effectiveness of multiple interventions targeting consumer behaviour implemented simultaneously is virtually non-existent (OECD, 2010b). However, a modelling by the OECD (2010b) has shown that health impacts of a combination of five policy instruments were up to twice as large as those attributable to the single most effective intervention, while the cost-effectiveness profile of the multiple-intervention strategy is very similar to that of the single most effective intervention. The cost of delivering the package of interventions varied between 12 and 24 USD PPP per capita in the different countries.

5 Abatement potential and costs of policy packages

5.1 Abatement potentials

5.1.1 Policy package healthy diet

The Healthy diet option is defined as: reducing intake to a healthy level (calories, overall protein): reducing daily intake to 2,500 kilocalories and eating 500 grams of fruits and vegetables, in line with WHO/FAO recommendations. This in turn limits the total fat to 30% of calorie intake and saturated fatty acids to 10%, reducing sugar intake to 10% of total calorie intake and limiting salt intake to a maximum of 5 grams per day.
This option is two folded:

- reduction of intake per head to 2,500 kilocalories per day; and
- increase fruits and vegetables consumption to 500 gram per day.

Thus the policy package will be analysed on its impact reducing kilocalories and increasing fruit and vegetables consumption on these two folds. Additionally as the policy package contains three measures which may be implemented separately or in combination. To assess the impact of the policy package, its policy measures are specified in more details.

It seems that, for healthy diets, knowledge about the healthiness of specific products, habits, socio-economic status, the obesogenic environment and economic barriers conspire to make healthy choices very hard. All of these barriers are important, although one can argue that economic barriers are less important than the other barriers, because food products are mostly very price-inelastic. Since the interaction and the interlinking of the barriers for an healthy diet is complex the policy packages should not only address these barriers one dimensional but synergy of the package should be taken into account. And as stated before policy packages should take different consumer segments into account (Policies to encourage sustainable consumption, European commission-DG ENV, September 2011). A survey of national policies covering OECD and other EU countries shows that governments are stepping up efforts to promote a culture of healthy eating and active living. Most have initiatives aimed at school-age children, such as changes in school meals and vending machines, better facilities for physical activity and health education. Many also disseminate nutrition guidelines and health promotion messages such as encouraging ‘active transport’ – cycling and walking – and ‘active leisure’. Governments are reluctant to use regulation and fiscal levers because of the complex regulatory process, the enforcement costs, and the likelihood of confrontation with key industries (OECD, 2010b).

Based on these considerations the following policy package could be effective:

- *Regulation introducing mandatory nutrition labelling*, containing nutritional information of all food products. This can have several effects. First, it can address the knowledge barrier and will make it more clear to consumers which products are healthy and which are not. Second, it can affect the production of healthy foods, as food manufacturers prefer to produce products which will be allowed to be described as healthy, thus targeting the infrastructural barrier of the availability of unhealthy food products.
- *Financing school-based intervention programs* and education of healthy eating; habits develop early in life, and it is therefore important to help children develop healthy habits at a young age. A large majority of OECD countries have adopted initiatives aimed at school-age children. These entail a variety of measures, often combined for greater impact. Measures include changes in the school environment, sometimes limited to improving school canteen menus, often through re-negotiation of contracts with external caterers. But in many cases they extend to improvements in facilities for physical activity and to changes in the types of food and beverages sold by vending machines and other outlets within schools. Interventions generally involve an educational component as well, entailing the inclusion in school curriculum of health and lifestyle education aimed at improving children's health literacy. It is not uncommon for such initiatives to involve children's families. Additionally, these programmes can be supported by the distribution of discount vouchers or even free food, such as fruit. On the other hand, they rarely involve individualised health checks. This package has a clear link to other EU objectives, and examples of EU interventions exist (School Milk Programme, Food intervention programme on deprived households).
- *Introducing consumption taxes*; to tackle the economic barriers to healthy consumption as changes in the context and the immediate consequences of behaviour. This approach through regulation and fiscal measures is more transparent but it hits all consumers indiscriminately, so can have high political and welfare costs. It may also be difficult to organise and enforce and have regressive effects. Concerted policy instruments on income-inequality should be employed, as people with low socio-economic status have poorer diets than people with high socio-economic status. In practise this would mean modulation of the VAT. E.g. this could be tax reduction/exemption for high value adding, and relatively high prices fruit and vegetables.

Regional difference:

There is no strong evidence that different regions will react differently. The only factor which is raised in the literature is that policy measures are most influence at regions with high required impact (IVM et al., 2008). This means that regions where people are consuming the nearest to 2,500 kcal (or to 500 gram of fruits and vegetables) will experience the least impact of the policy measures. We differentiate the impact of the healthy diet option on regions according to the difference between their BAU situation.

Regulation introducing mandatory nutrition labelling

The EU imposes some regulations on food labelling (Directive 2000/13/EC, last updated in 2009) on labelling, presentation and advertising of foodstuff. Pre-packaged foodstuffs must comply with the rules on labeling, presentation and advertising of foodstuffs. These rules are harmonised at European Union (EU) level to enable European consumers to make informed choices and to remove obstacles to the free circulation of foodstuffs and unequal conditions of competition. The Directive applies to pre-packaged foodstuffs to be delivered

to the final consumer or to restaurants, hospitals, canteens and other similar mass caterers.
An other regulation is the Regulation (EC) No 1924/2006 of the European Parliament and of the Council of 20 December 2006 (updated in 2008) on nutrition and health claims made on foods. This Regulation establishes the authorisation procedures required to ensure that claims on food labeling, presentation and advertising are clear, concise and based on evidence accepted by the whole scientific community.The labelling is expected to enable informed choices about the food consumers buy. There are many initiatives to introduce relevant labelling criteria within the EU (e.g. on product origins and the environmental and energy intensity embodied within).

Going beyond nutrition related labelling, HG label is an alternative labelling concept based on two dimensions: the health level and additional carbon emissions. The carbon emission index is based on similar tools which are used in the carbon emission labels (see also labelling an policy option Reduced animal protein intake), while the health level is based on a number of health criteria (number of calories, and fat and mineral distributions (Termac, 2011). HG label focuses only on food products.

The impact of labelling (which is called framing) on consumption per capita to aim towards the maximum impact is influenced by some factors, such as the standardisation and quality of the labels, the consumer trust and their choice behaviour, elasticity of demand per product and labels relative to other products. In Section 4.3.4. several reports on different policy measure and their effect were cited, especially the OECD report (2010b) on empirical findings policy measurements and stimulation of a healthy diet. A more detailed and specific search was done on the impact of labelling on health diet. Several studies attempt to quantify the estimation of the potential impact of labelling on consumption of certain products or services such as in Kooreman (2000); Eply et al. (2006); Abeler and Marklein (2008) and Verhoef (2010).

In order to use labelling in an optimal way, it is necessary to fully understand the effects labelling could have on choice behaviour and which groups are the most affected by this mechanism. Labels should be able to distinguish the benefit and harm clearly on the consumers' health.
In Table 26 we provide an outline of the impact of labelling on consumption patterns as found by several studies.

Table 26 Results of a number of studies on the impact of labelling (per year)

Study	Main topic - all related to labelling on food?	Impact difference on healthy consumption related to labelling according to the experiment	Average (min.; max.)
Kooreman (2000)	Children products	9% difference on consumption	
Abeler and Markein (2008)	Wine consumption	5% difference on wine consumption	
Epley et al. (2006)	Bonus impact	2.5% difference on healthy consumption	
Verhoef (2010)	Several experiments on purchasing of Drinks vs. books	From 6% up to 11.5% difference to consumption	
BIOis, et al. (2011)	Food and health	10% difference on consumption of fruit and vegetables	
Variyam and Cowly (2006); Variyam (2008) and Sassi-OECD (2011)	Food	10% difference on consumption	
			7.5 % (min: 2.5 ; max: 11.5)

The impact of labelling depends on many factors, as discussed above. Here we illustratively take the average of the studies reviewed in this report, 7.5%, as the impact of labelling. This is interpreted as a 7.5% reduction of the difference between the amount of food of different categories consumed in the current diet and the in the healthy diet.

Mass media campaigns

Section 4.2.5 estimates the effects of mass-media campaigns to promote a healthier diet to of the same order of magnitude as the impact from nutritional labelling. Actually, the effects are somewhat higher. We have therefore illustratively estimated the effect of mass media campaigns to be a 10% reduction of the difference in consumption between the current diet and the healthy diet.

Financing school-based intervention programs and education

As we suggested in the policy package, intervention can be on three aspects:
1. Adjust menus in the school canteens.
2. Incorporate the healthy diet in the curriculum.
3. Promote activities and sports within the schools.

To analyse the impact of this policy measure we focus on intervention 1 and 2 as these are directly related to the healthy option as defined in this study.

1. Interventions on the school canteen and its menus may be achieved by:
   a Providing specific dietary guidelines to schools incorporating age categories.
   b Provide fiscal disadvantages for snacks which are located near schools unless they comply with the dietary guidelines.
   c Limit the existing of vending machines at schools and support machines providing alternative healthy products.
2. Interventions on education programs to include healthy- diet may be:

a Introduce educational curriculums which aim to incorporate the impact of healthy diet on overall health.
b Hold mandatory students-parents educational workshops to address the important of healthy diet and highlight the impact of unhealthy consumptions.

Section 4.3.4 states 'Habits develop early in life, and it is therefore important to help children develop healthy habits at a young age. Another way in which habits can be targeted is by using 'upstream' interventions, such as changes in the context and the immediate consequences of behaviour (Verplanken and Wood, 2006)'. Research shows that school-based intervention can successfully change food choices (De Bruijn et al. (2005) and sometime pupils' habits (Reinaerts et al., 2007). The OECD (2010b) estimates that such interventions are likely to increase fruit and vegetable consumption with 38 grams per day for each pupil that is exposed to the intervention (Section 4.2.5). A more detailed and specific search was done on the impact of school based interventions programmes.
The impact of interventions on school canteen and its menus on the consumption per capita (to meet the criteria of the healthy diet) is large and can achieve an increase in the consumption of fruits per day up to 46% and reduce the total intake of calories and fat per day to up to 5%. Of course the impact of their policy measure mainly concerns children at school (target group) but various effects are mentioned as: effect on knowledge and awareness of parents in their food choice behaviour. But never the less this instrument has a more strategic impact than others mentioned in the policy package for the option healthy diet, e.g. labelling and VAT.
The following table summarises the potential impact as mentioned in several studies:

Table 27 Summary of impact from financing school-based intervention programs and education (per year)

Study	Key issues	Impact on fruit and vegetable consumption	Average (min.; max.)
NSW government action plan 2003-2007	Healthy menu at school canteens	45%	
OECD (2011)	Healthy diet at school	46%	
BIOis et al. (2011)	School-based interventions	38%	
			43 (38 ; 46)

School-based intervention targets school-going children. They form habits to which a share of them sticks when they grow older. As a result, an increasing part of the population changes their behaviour. In order to quantify the share of the population influenced by the school based intervention, four assumptions have to be made:

1. The school-going age groups – in this study we have assumed that the age groups 5-9 and 10-14 are the main target groups.
2. The share of pupils in this age group that would be reached by the policy – in this study we illustratively assumed this share to be 50% because not all schools may join a government programme, pupils will not attend school or drop out, et cetera.
3. The start of the school-based intervention – in this study we have assumed that a programme would start in 2015.

4. Whether or not parents of school-going children will change their behaviour – in this study we have conservatively assumed that they would not. This relieves us of the methodological difficulty of assessing the age groups of the parents, the share of non-parents in these age groups, the family structures, et cetera.

Under these assumptions, Table 28 shows the share of the population that is reached by the school-based intervention in 2020, 2030 and 2050.

Table 28 Share of population affected by the school-based intervention

Year	Age groups affected	Share of population
2020	5-19	8%
2030	5-29	13%
2050	5-49	24%

Bron: Own calculations based on EUROPOP 2010.

In order to quantify the impact of the policy, we assume that the population reached by the school-based intervention, as presented in Table 28, will reduce the difference between the amount of food of different categories consumed in the current diet and the in the healthy diet by 43%, the average empirical effect of school-based intervention as presented in Table 27.

Introducing consumption taxes

The impact of consumption taxes on food consumption (VAT) is complex to determine as it is affected not only by its value and the prices of the products but also by the choice behaviour of customers and the discount period. This tool which is transparent, has been extensively used by the different member states in their attempt to encourage the consumption of green products. Most member states apply a reduced VAT rate to food and food products which varies between 0% and 21%.
Achieving the optimal impact of introducing VAT rule to encourage consumption towards the healthy diet (as defined in this study), several issues need to be taken into account. These issues were extensively elaborated in a study for the commission conducted by IVM, Oosterhuis et al., (2008).The conclusion for the preferred scenario (more consumption of fruit and vegetables and less calories form fats and carbohydrates) price and demand elasticity important is to analyse for impact assessment. The impact of changes in consumption patterns due to changes in the VAT depends on the product itself, its demand and its cross demand elasticity; the market share and average income. In general food elasticity of demand is relatively low. To aim to achieve the optimal impact, it is crucial to understand the demand elasticity of each product to understand the potential reaction to VAT changes. Table XX4 aims to provide an illustration of demand elasticity of the food sub-groups within Europe. The lower the demand elasticity, the less the achieved impact on change in VAT. For instance, the demand on the fats oil will probably be affected larger than the demand on meat if VAT of both products change equally.

Fiscal incentives can directly affect consumption behaviours, and therefore influence lifestyle choices (OECD, 2010b). As mentioned above, several studies suggest that consumption taxes can have an impact on consumption of unhealthy foods (OECD, 2010b; Powell and Chaloupka, 2009). A more detailed and specific search was done on the impact of VAT in term of overall effects.

Table 29 **Summarise the findings of several studies on VAT impact**

Study	Main topic - all related to VAT	Impact difference related to VAT according to experiment	Average (min.; max.)
BIOis et al. (2011)	Consumption taxes	4-11%	
Bahl et al. (2003)	Soft drinks	6.8-15%	
Jensen and Smed (2007)	Food and nutrients; VAT decreased on fruits and vegetable consumption by Danish households	2.5-6.5% (assumed own price elasticity of fruit and vegetable consumption - 0.7)	
Dong and Ling (2009)	Fruit and vegetable consumption of American low income households	Assumed own price elasticity of fruit and vegetable consumption 0.21-0.52	
Gabe (2008)	Soft drinks	3.2-4.8%	

Based on this table, we assume that a reduced VAT rate on fruit and vegetables resulting in a price decrease of 6%, would result in a 3% higher consumption. Generally, we have modelled a change in consumption of different food items of 3% as a result of changes in tax rates or excise duties. This is a crude assumption used for illustrative purposes only.
Table 30 provide the average impact of the package **as a whole** (contributing of the three policy measures).

Table 30 **The total impact of the policy package (Healthy Diet)**

The policy measure	2020	2030	2050
Labelling	7.5%	7.5%	7.5%
Mass media campaigns	10%	10%	10%
School-based intervention	3.4%	5.7%	10.4%
VAT and excises	3%	3%	3%
Total impact (= reduction of difference in consumption of food products between current diet and healthy diet)	22%	24%	28%

Table 31 **The total impact of the policy package on the change towards a healthy diet, 2020, 2030 and 2050**

(Kg/head)	European Union (27 countries) Current diet	European Union (27 countries) *2020 diet*	European Union (27 countries) *2030 diet*	European Union (27 countries) *2050 diet*
Cereals (including bread)	121	113	113	111
Rice	5	5	5	4
Beef	17	16	16	16
Pork	41	38	38	38
Sheep & Goat	4	3	3	3
Poultry	21	20	20	19
Equidae	1	1	1	1
Milk	84	79	78	77
Cheese & Butter	20	19	19	19
Eggs	13	12	12	12
Veg. fats & Oils	18	17	17	16

(Kg/head)	European Union (27 countries) Current diet	European Union (27 countries) *2020 diet*	European Union (27 countries) *2030 diet*	European Union (27 countries) *2050 diet*
Fresh fruits	95	95	95	94
Nuts & Dried fruits	8	8	7	7
Vegetable (no potatoes)	133	125	124	123
Potatoes	79	74	74	73
Sugar	34	32	31	31
Wine (lt/head)	29	27	27	27

The biggest change in diet is in consumption of cereals and animal related products, in line with the impact of reducing kcal to 2,500 in the healthy diet option.

As has been discussed, knowledge, habits, socio-economic status, infrastructural and economic factors are the most important barriers in general for a change to a healthy diet. It is unlikely that these barriers can be overcome in the short term, but on the long term educational interventions and laws can slowly nudge people in the proposed direction. A first relevant policy instruments that addresses this consists of school-based intervention programs (Reinaerts et al., 2007). Habits develop early in life, and it is therefore important to help children develop healthy habits at a young age. Another way in which habits can be targeted is by using 'upstream' interventions, such as changes in the context and the immediate consequences of behaviour (Verplanken and Wood, 2006).

As also discussed before the time sequence of the three policy measures is different. As the policy measures labelling and VAT have an direct impact on the consumer and their purchase behaviour towards healthy diet, the impact policy measure school based intervention is long term. This measure affect the school going generation and the actual impact will last for at least 10 years later.

Table 32 shows the estimated impact of the healthy diet policy package on GHG emissions in 2020, 2030 and 2050.

Table 32 Impact of the healthy diet policy package on GHG emissions, 2020, 2030 and 2050

	2020	2030	2050
Projected population EU-27 (millions)	514	522	524
BAU food emissions (Mt CO_2 eq.)	651	661	663
Of which: in EU (Mt CO_2 eq.)	544	552	554
Of which: outside EU (Mt CO_2 eq.)	107	108	109
Emissions healthy diet policy package (Mt CO_2 eq.)	607	612	607
Of which: in EU (Mt CO_2 eq.)	507	512	507
Of which: outside EU (Mt CO_2 eq.)	100	101	100

	2020	2030	2050
Total difference ($Mt\ CO_2$ eq.)	44	48	56
Of which: in EU ($Mt\ CO_2$ eq.)	37	41	47
Of which: outside EU ($Mt\ CO_2$ eq.)	7	8	9

5.1.2 Policy package reduced animal protein intake

Identifying and categorising barriers for behavioural change

The option Vegetarian Diet and a Diet with Reduced Animal Protein intake both (Less animal Protein option) have as the main objective a reduction of GHG emissions. Hence, they have similar barriers for similar consumer segments. A healthy diet has a different purpose, has different advantages and disadvantages for consumers and as a consequence different barriers. The Less Animal Protein option is defined as: One day a week no consumption of any animal protein (including all dairy products and eggs). This is account for 14% less of the total animal protein consumption per year. This will be substituted by cereals and vegetables.
To assess the impact of the related policy package we follow the exact line and use the same literature to indicate impact on the BAU levels. Until now no empirical study provides us with more insights about effect of environmental labelling on products. Qualitative studies on fair trade and carbon food prints are used and indicative studies.
The impact of each policy measure within the package:

Introduce differentiated consumption taxes based on the environmental performance of products (e.g. animal protein consumption taxes)

Most member states apply a reduced VAT rate to food and food products which varies between 0% and 21%. Achieving the optimal impact of introducing VAT rule to encourage reduced intake of animal proteins (as defined in this study), several issues need to be taken into account. These issues were extensively elaborated in a study for the commission conducted by IVM, Oosterhuis et al., (2008). This study looks at the potential impacts of changing current VAT rates to align them with environmental goals in some specific cases - domestic energy supply (where there are currently reduced rates in some countries), food and dairy products, insulation materials, white goods and boilers. It finds that the suitability of differential VAT as a policy instrument differs greatly across products, in particular depending on the nature of the market failure in consumer behaviour which the VAT rate would be trying to correct. The example given is the fact the demand for meat and dairy products is price inelastic. Based on this fact, a 12% price increase would be expected to reduce demand for meat in the EU between 2 and 7%, and for dairy products between 2 and 5%. This could bring about a gross reduction in greenhouse gas emissions of between 9.2 and 27.5 million tonnes CO_2 equivalent for meat and between 3.4 and 6.9 million tonnes CO_2 equivalent for dairy products. The impact of changes in consumption patterns due to changes in the VAT depends on the product itself, its demand and its cross demand elasticity; the market share and average income. In general food elasticity of demand is relatively low. To aim to achieve the optimal impact, it is crucial to understand the demand elasticity of each product to understand the potential reaction to VAT changes. The lower the demand elasticity, the less the achieved impact on change in VAT. For instance, the demand on the fats oil will probably be affected larger than the demand on meat if VAT of both products change equally.

As above the average of the literature on the effect of VAT is summarised in Table 33.

Table 33 **Summarise the findings of several studies on VAT impact**

Study	Main topic - all related to VAT	Impact difference related to an average 12% increase in VAT rate
IVM et al. (2008)	Meat	2-5% (elasticity of demand is estimated at 0.2-0.4)
IVM et al. (2008)	Dairy	2-7% (elasticity of demand is estimated at 0.2-0.6)

Based in this evidence, we have modelled an increase of VAT rate on meat and dairy of 12% to result in a 5% decrease in consumption.

EU-level sustainable food labelling scheme and credible certification mechanisms

No empiric study on effect of environmental labelling or carbon labelling and consumers change in diet is found, only some qualitative data is available. Although this table is strongly related to, similarities between labelling and health and with environmental labels e.g. carbon food print and fair trade, can be mentioned. The information digestions and the purchase decision 'on the spot' is quite similar for both items; those mechanism are comparable. But regarding differences issues as consumer perception on short and long term effect of the purchase decision as the interaction toward the value system of the consumer need to be mentioned. These issues prevent until now to produce a coherent and consistent labelling tool across the EU (BIOis, et al., 2011). There would be a need to develop an EU level emission food labelling scheme and establish credible certification mechanisms in order to enable consumers to more easily distinguish between sustainable and non-sustainable products (BIOis, et al., 2011). Some suggestions could be introducing the eco-labelling , energy, carbon emission or HG labelling.

The eco-labelling is applied into food and, more intensively, the automobile and electronica industries. Eco-labelling in food is mostly voluntarily and is a form of sustainability measurement directed at consumers, intended to make it easy to take environmental concerns into account when shopping. There are several forms of these Eco-labels, some quantify pollution or energy consumption by way of index scores or units of measurement; others simply assert compliance with a set of practices or minimum requirements for sustainability or reduction of harm to the environment (Erskine and Collins, 1997). The past few years experienced an explosion in the numbers of different eco-labelling programs across the world and across business sectors, with many schemes broadening their issues to cover social, ethical and safety issues as well as environmental. This has led to some confusion and perhaps fatigue among consumers. Brand awareness of most labels (such as the EU Eco-label) remains low.

The EU Eco-label is a voluntary scheme, established in 1992 to encourage businesses to market products and services that are kinder to the environment (EC-Env). The labels are awarded according to environmental criteria set by the member states of the EU with involvement of industries, consumers and environmental NGOs and the European Commission of Environment.

Another example is the **Nordic Ecolabel** or **Nordic Swan,** which is the official sustainability eco-label for the Nordic European countries, introduced by the Nordic Council of Ministers. This is done by a voluntary license system where the applicant agrees to follow a certain set of criteria outlined by the

Nordic Eco-labelling in cooperation with stakeholders. Some eco-labels among which are Marine stewardship council and Friends of the sea, target only seafood.
Energy labelling indicates whether or not products are energy efficient compared to similar products. Common labels include the European Union energy label and the Energy Saving Trust Recommended logo administrated by the Energy Saving Trust in the United Kingdom. These labels document how much energy an appliance consumes while being used; energy input labelling documents how much energy is used to manufacture the product, an additional consideration in the full life cycle use of product.
Carbon emission labels are an alternative methodology for certification, examining impact on green- house gas emissions rather than the direct energy use. This information is important to consumers wishing to minimise their ecological footprint and contribution to global warming made by their purchases. Some of the labels include the EKO energy label in Finland, and the discontinued Eugene Green Energy Standard in the European Union.
Purchases based on Health labels have an direct effect on de consumer at short terms purchases related to Environmental labelling have an indirect effect on the consumer and the impact is perceived long term. Main determinant is the values system of the consumer which is in the health labelling option individual related (affect personal wellbeing) and in the second option society related (affects society wellbeing in the long term). In fact the environmental labels seems to have effect on a far more target groups of consumers than health labelling (D'Souza, 2006). Hence, it is unlikely that a consumer pays attention to an environmental label unless he or she values protecting the environment, perceives buying (more) environmentally friendly products as an effective means to achieve this goal, and perceives the information that the label conveys as useful for this purpose. In addition, the availability of eco-labelled products in the shops and the consumer's ability to recognise and understand them undoubtedly influences attention towards this type of labels (Thøgersen, 2010).

So while it is reasonable to expect some results of a carbon footprint label on a small share of the population, we have little empirical evidence. More evidence is available for health labelling (see Section 5.1.1) and perhaps a combined health-environment label may have a larger effect. Here, we have illustratively modelled the impact of an environmental label to be a 0.5% reduction in consumption of meat and dairy products.

Table 34 provides the average impact of the package as a whole.

Table 34 The total impact of the policy package (Reduced Animal Protein Diet)

The policy measure	Impact on animal protein consumption
Labelling	0.5%
VAT	5.0%
Total (sum)	5.5%

Table 35 provides the total impact of the policy package on the BAU situation towards the Reduced animal protein intake in 2020. The diet and emissions are presented for 2020, but because the diet and the population are projected to remain constant over time, the situation in 2030 and 2050 is not significantly different.

Table 35 The total impact of the policy package on the BAU situation towards the reduced animal protein intake

Food item	European Union (27 countries) BAU diet (kg/head)	*Total emissions 2020 (Mt CO_2 eq.)*	European Union (27 countries) Diet after implementation of policy package (kg/head)	*Total emissions 2020* after implementation of policy package *(Mt CO_2 eq.)*
Cereals (including bread)	121	65	122	65
Rice	5	7	5	7
Beef	17	162	17	161
Pork	41	91	41	90
Sheep & Goat	4	30	3	30
Poultry	21	27	21	27
Equidae	1	7	1	7
Milk	84	46	83	46
Cheese & Butter	20	66	20	65
Eggs	13	11	13	11
Veg. fats & Oils	18	16	18	16
Fresh fruits	95	21	95	21
Nuts & Dried fruits	8	3	8	3
Vegetable (no potatoes)	133	52	134	53
Potatoes	79	23	79	23
Sugar	34	9	34	9
Wine (lt/head)	29	14	29	14
Total		651		648

The policy package elements considered in this policy package would result in only small decreases of greenhouse gas emissions. The reason is that there is much less evidence on the effectiveness of policies to reduce the environmental impact of food than evidence on policies to improve the healthiness of diets.

5.1.3 Discussion

In Section 4.2.5 states 'Overall, the effects of nutrition labelling on actual consumer behaviour appears to be small (Upham et al., 2011)', food purchase is mainly a habit of routine. Also is stated to arise awareness labelling is still important and if labelling is based on transparent criteria (e.g. noticeable/ distinctive, trusted source of information, simple to understand and intuitive, Berry, Crossley and Jewell, 2008; Upham, Dendler and Bleda, 2010) trustful for the consumer as a guideline for choices. And there the effect of nutrition labelling is significant but small (OECD, 2010b).
At the EU level environmental aspects or the EU Eco-labels may be included into the mandatory food nutrient labels (expected to be launched in 2014) incorporating innovative forms of labelling such as the HG label. For the consumers this additional labelling information has to be put in a context as a references to make choices in purchases.

Evidence of the combined effectiveness of multiple interventions targeting consumer behaviour implemented simultaneously is virtually non-existent (OECD, 2010b). It is therefore difficult to predict whether combinations of interventions would create synergies which would translate into an overall effect larger than the sum of individual intervention effects, or whether adding interventions to a prevention strategy would have decreasing incremental returns. However, the OECD (2010b) has used a micro-simulation model to assess at least some of the effects to be expected from combining multiple interventions into a prevention strategy which targets different population groups. The assumption made in this analysis was a conservative one, estimating that the overall effect of interventions is less than additive relative to the effects of individual interventions. A combination of five policy instruments (including labelling and school-based interventions) was explored. The results of the analysis showed that impacts were up to twice as large as those attributable to the single most effective intervention, while the cost-effectiveness profile of the multiple-intervention strategy is very similar to that of the single most effective intervention.

5.2 Costs

In this paragraph the government costs for implementing the policy packages in the domain food are analysed. The policy packages considered are the following:
- mass media campaigns;
- school-based interventions;
- fiscal measures;
- compulsory food labelling.

The government costs for the policy package on food are calculated by using OECD data (OECD, 2010b). The original data were expressed in US$ ppp in 2005 and are converted to Euros ppp for 2010, corrected for inflation. The government costs are shown in a cost-range, based on five OECD countries (Mexico, Japan, Canada, Italy and England). Unfortunately it was not possible to exclude the non-EU countries. Impact and evaluation studies on food labelling and fat taxes could not provide us with more information on implementation costs for governments on EU level[8]. In the studies that have been researched mostly costs were expressed on firm- or industry base.

The implementation costs for the behavioural measures of the two policy packages for the government are shown in Table 36.

Table 36 Implementation cost policy package

Policy package costs (healthy diet)	Cost per person (in € ppp) 2010		Total costs (in mln. €) 2010 for EU-27	
Healthy diet	**Min. costs**	**Max. costs**	**Min. costs (in mln. €)**	**Max. costs (in mln. €)**
Regulation introducing mandatory nutrition labelling	0.25	0.85	127	424
Financing school-based intervention programs	0.77	1.54	60	120

8 Studies that have been researched include:
EC(2008), Impact Assessment Report on Nutritional Labelling Issues.
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Policy package costs (healthy diet)	Cost per person (in € ppp) 2010		Total costs (in mln. €) 2010 for EU-27	
Healthy diet	**Min. costs**	**Max. costs**	**Min. costs (in mln. €)**	**Max. costs (in mln. €)**
Targeted information and awareness raising campaigns and education programme	0.38	1.54	193	771
Introducing consumption taxes	0.02	0.10	12	50
Total cost			*392*	*1.366*
Vegetarian diet and reduced meat diet	**Min. costs**	**Max. costs**	**Min. costs (in mln. €)**	**Max. costs (in mln. €)**
Introduce differentiated consumption taxes based on the environmental performance of products	0.02	0.10	12	50
Develop an EU-level sustainable food labelling scheme and establish credible certification mechanisms	0.25	0.85	127	424
Launch targeted information and awareness-raising campaigns and education programmes.	0.38	1.54	30	120
Total cost			*169*	*594*

Source: OECD (2010b) and Eurostat.

Compulsory food labelling

The estimated cost of per capita of introducing compulsory food labelling regulation in the EU ranges between € 0.25 and € 0.85. The costs of the intervention include basic administration, planning, enforcement, preparation and distribution of posters and, finally, resources needed to manage the programme of food inspection. The programme does not account for the additional packaging costs associated with designing and printing nutrition labels and for the potential cost associated with the reformulation of certain foods, likely to be borne by the private sector (OECD, 2010b).

School-based interventions

The estimated cost per capita of a school-based intervention in the EU ranges between € 0.77 and € 1.54. About half of this is spent in programme organisation costs, while the remaining half is split between training of teachers and food service staff, extra teaching and additional curricular activities, e.g. guest speakers, brochures, books, posters and equipment. The single most expensive item is extra teaching hours. Costs do not include changes in food service contracts, vouchers/coupons from sponsors and school nurse time (OECD, 2010b).

Mass media campaigns

The estimated cost of per capita of a mass media campaign in the EU ranges between € 0.38 and € 1.54. Almost two-thirds of this cost is spent in broadcasting advertisements on national and local radio and television channels and on producing and distributing flyers and leaflets. The remaining resources are mainly devoted to hiring personnel to design, run and supervise the programme (OECD, 2010b).

Fiscal measures

The estimated cost of per capita of fiscal measures in the EU ranges between € 0.02 and € 0.10. Basic administration, planning, monitoring and enforcement at the national level are included in these costs. Enforcement in particular, accounts for most of the cost. Potential revenues from the tax, as well as expenditures originating from the subsidy, are not accounted for in the analysis, as they represent transfers rather than costs. Tax operating costs are not included (OECD, 2010b).

Total direct costs

The total direct costs of the behavioural measures are calculated by multiplying the costs per person by the total EU-27 population. In case of the school based interventions and the targeted information and awareness-raising campaigns, the number of children in the EU-27 in the age range of 0-14 years is used. Data for these calculations are retrieved from Eurostat.

The total government costs for the EU-27 when all behavioural measures of the healthy diet policy package would be implemented range from € 392 mln. to € 1.366 mln. Uncertainty applies to these numbers since these are estimates that are based of five OECD countries, of which also non EU are included.

The total costs for the vegetarian and reduced meat policy package are estimated to range between € 169 mln. and € 594 mln. The same uncertainties apply in this case due to inclusion of non-EU countries in the cost analysis.

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In: Energy Policy, Vol. 24, No. 9 (1996); p. 795–803

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Annex A Emissions Factors of food products

Table 37 Emission Factors of food products

Food product	Life cycle CO_2 eq. emissions (kg/kg)
Cereals	1.05
Rice	2.97
Beef	18.24
Pork	4.29
Sheep & Goat	16.60
Poultry	2.50
Equidae	16.60
Milk	1.07
Cheese & Butter	6.35
Eggs	1.60
Veg. fats & Oils	1.72
Fresh Fruits	0.42
Nuts & Dried fruits	0.82
Vegetable (no potatoes)	0.76
Potatoes	0.57
Sugar	0.51
Wine (lt/head)	0.95

Source: Leip et al. (2010) for beef, milk, pork, sheep and goat, poultry and eggs and Blonk et al. (2008) for other food products.

Annex B Factsheets Food and Drink

B.1 Blonk et al., 2008

Blonk, H., Kool, A., & Luske, B, De Waart, S. (2008), Environmental effects of protein-rich food products in the Netherlands: Consequences of animal protein substitutes	
Description of study	
Description of behavioural mitigation measure	Changing from a diet rich in animal proteins to a diet rich in vegetable proteins
Description of BAU scenario applied	Current consumption levels of animal and vegetable proteins served as the BAU scenario
Time horizon of the study	No time horizon is mentioned in the study
Scope of the study	The geographical scope of the study is the Netherlands
Assessment method applied	A Life Cycle Analysis was made of the average production chain of protein products in the Dutch market to calculate their greenhouse effect, fossil energy consumption and land occupation. For animal products the production of feed components, the transport and the processing of feed, the feed conversion rate and manure management were to were used to estimate energy use, GHG emissions and food kilometres. In addition to a diet with the current consumption levels of animal and vegetable proteins, four hypothetical diets were compiled: - A classic diet (including meat and dairy) which meets recommendations for healthy food consumption. - A totally vegan diet (no animal proteins). - A diet with one meat-free dinner a week. - A diet with one meat-free day a week.
Data sources used	Data about the production chains of the protein rich products were obtained from national information guides and databases, the international literature, FAO data on fertilizer use and yields, and directly from food companies. Data from companies were often the only available recent source for information on processed (vegetarian) products. Data on diets from the Dutch food consumption survey (VCP) were used to estimate current animal and vegetable protein consumption.
Mitigation potential	
Direct effects	Reduction potential as compared with current diet: Diet 1 – 1.4 megatonnes CO_2 eq./year. Diet 2 – 6 megatonnes CO_2 eq./year. Diet 3 – 0.6 megatonnes CO_2 eq./year. Diet 4 – 0.5 – 1.1 megatonnes CO_2 eq./year. Additional results: the type of meat also matters. If only chicken meat was consumed, CO_2 emissions would be reduced by 3.5 megatonnes CO_2 eq./year. Replacing meat with dairy products does not generally bring about a reduction.
Indirect effects	No indirect effects are taken into account in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	A reduction in consumption of animal proteins would reduce the area of land needed to produce protein products. An entirely vegan diet, for instance, would reduce the area of land needed to produce protein products by 12,500 km^2/year.
Additional remarks	

B.2 Kool et al., 2010

Kool, A., Blonk, H., Ponsioen, T., Sukkel, W., Vermeer, H., De Vries, J., & Hoste, R. (2010), Carbon footprints of conventional and organic pork: Assessments of typical production systems in the Netherlands, Denmark, England and Germany	
Description of study	
Description of behavioural mitigation measure	Production of pork, conventional and organic
Description of BAU scenario applied	No BAU scenario was applied. CO_2 emissions that are associated with current pork production practices were estimated.
Time horizon of the study	No time horizon is mentioned
Scope of the study	The Netherlands, Denmark, England, Germany
Assessment method applied	Life Cycle Analyses were used to estimate the contribution of a products' lifecycle to environmental indicators, such as greenhouse gas emissions. All emissions that are associated with the production process up to and including the slaughterhouse were included. Emissions as a result of cooling and transport after the slaughterhouse were not taken into account.
Data sources used	IPCC guidelines for performing national inventories on greenhouse gasses were used. In the present study the guidelines of 2006 were used.
Mitigation potential	
Direct effects	The carbon footprint of conventional pork was estimated between 3.5 and 3.7 and 3.7 kg CO_2 eq. per kg pork. This did not differ between countries. The carbon footprint of organic pork was estimated between 4.0 and 5.0 kg CO_2 eq. per kg pork. Production of feed (crop growing, transport of crop products, processing crop products, transport of raw materials and feed mixing) contributes roughly 50-60% to the carbon footprints of conventional and organic pork. For most systems, the second most important source is methane emissions from manure storage (12-17%).In systems with a substantial share of grazing (organic systems in Denmark and England), the emissions from grazing are the second most important source. Several reduction measures are identified, but no quantitative assessments of reduction potential is given: - Better feed composition can reduce CO_2 emissions by 5-7.5%. - Better feed use can reduce CO_2 emissions by 10%. - Using wet co-products as feed can reduce CO_2 emissions by 10% on the condition that these products are produced nearby. - Storage of manure. - Digestions of manure.
Indirect effects	No indirect effects are taken into account in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	No specific side-effects were identified and/or quantified in this study
Additional remarks	

B.3 Stehfest et al., 2009

Stehfest, E., Bouwman, L., Van Vuuren, D. P., Den Elzen, M. G. J., Eickhout, B., & Kabat, P. (2009), Climate benefits of changing diet	
Description of study	
Description of behavioural mitigation measure	Change to a low animal protein diet
Description of BAU scenario applied	In the BAU scenario, a possible future is portrayed with default assumptions on meat consumption (i.e., an income-driven increase in per capita meat consumption), and no climate policy.
Time horizon of the study	Present–2050
Scope of the study	Worldwide
Assessment method applied	An integrated assessment model (IMAGE) was used to explore the long-term dynamics of global change as a function of drivers such as demographic and economic development. In order to explore the impact of dietary transitions, four variants of the BAU scenario were developed with partial or complete substitution of meat by plant proteins. These four variants are (a) complete substitution of meat from ruminants (NoRM), (b) complete substitution of all meat (NoM), (c) complete substitution of all animal products (meat, dairy products and eggs) (NoAP) and finally (d) partial substitution of meat based on a healthy diet variant (*HealthyDiet*, HDiet).
Data sources used	Greenhouse gas emissions are mainly computed on the basis of guidelines of the Intergovernmental Panel on Climate Change. For agricultural production, the IMAGE model was calibrated to follow the projections of the FAO for 2000-2050.
Mitigation potential	
Direct effects	The healthy diet results in a reduction of GHG emissions of 10% as compared with the BAU scenario.
Indirect effects	No indirect effects are taken into account in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	A reduction in animal proteins also results in a dramatic decrease in land-use
Additional remarks	

B.4 Sukkel et al., 2010

Sukkel, W., Stilma, E., & Jansma, J. E. (2010), Verkenning van de milieueffecten van lokale productie en distributie in Almere (Exploration of the environmental effects of local production and distribution in Almere)	
Description of study	
Description of behavioural mitigation measure	Local production of food, plus use of renewable energy for production and distribution
Description of BAU scenario applied	In the BAU scenario, no local food production and no changes in the use of renewable energy for production and distribution is projected. This is compared with Scenario 1, in which 20% of food is produced locally and 20% of energy for production and distribution is renewable, and Scenario 2, in which 20% of food is produced locally and organically, and 100% of energy for production and distribution is renewable.
Time horizon of the study	The scenarios are estimated for the year 2030. However, for a number of variables, estimations are used which are reliable for the next 10 years.
Scope of the study	The geographical scope of the study is the city of Almere in the Netherlands. It is assumed that Almere will have 350.000 inhabitants in ten years, versus 188.000 now.
Assessment method applied	Life Cycle Analyses were used to estimate energy use, GHG emissions and food kilometres. Based on data on consumer spending on food and food consumption, the average food consumption for all inhabitants is estimated. Next, land-use, food kilometres, fossil fuel use and carbon food print that are associated with this estimation of food consumption are calculated. This is the BAU scenario. For Scenario 1, these numbers are again calculated for a situation in which 20% of food consumed is produced locally and 20% of energy used is renewable. For Scenario 2, these estimates are again calculated for a situation in which 20% of food is produced locally and organically, and 100% of energy for production and distribution is renewable.
Data sources used	Food consumption: RIVM Food Consumption Survey (VCP: Voedsel consumptive peiling) Land-use: KWIN (2006) Energy use: Bos et al. (2007)
Mitigation potential	
Direct effects	Results show that a percentage of locally produced foods of 19% is feasible. In Scenario 1, this percentage of locally produced foods in 2030 will lead to a reduction of 9,433 ton CO_2 emission per year as compared with the BAU scenario. In Scenario 2, this percentage of locally produced foods in 2030 will lead to a reduction of 27,100 ton CO_2 emission per year as compared with the BAU scenario. In the BAU scenario, a major part of energy use takes place in the primary production process. The reductions in the use of fossil fuels is mainly the result of the assumptions of renewable energy use in Scenario 1 and 2. Transport kilometres are responsible for a very small part of reductions in energy use, since many products that are produced locally in Scenario 1 and 2 are already produced in the Netherlands in the BAU.
Indirect effects	No indirect effects are taken into account in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	No specific side-effects were identified and/or quantified in this study
Additional remarks	

B.5 Blonk et al., 2008

Blonk, H., Kool, A., & Luske, B, De Waart, S. (2008), Environmental effects of protein-rich food products in the Netherlands: Consequences of animal protein substitutes	
Description of study	
Description of behavioural mitigation measure	Changing from a diet rich in animal proteins to a diet rich in vegetable proteins
Description of BAU scenario applied	Current consumption levels of animal and vegetable proteins served as the BAU scenario.
Time horizon of the study	No time horizon is mentioned in the study
Scope of the study	The geographical scope of the study is the Netherlands
Assessment method applied	A Life Cycle Analysis was made of the average production chain of protein products in the Dutch market to calculate their greenhouse effect, fossil energy consumption and land occupation. For animal products the production of feed components, the transport and the processing of feed, the feed conversion rate and manure management were to were used to estimate energy use, GHG emissions and food kilometres. In addition to a diet with the current consumption levels of animal and vegetable proteins, four hypothetical diets were compiled: - A classic diet (including meat and dairy) which meets recommendations for healthy food consumption. - A totally vegan diet (no animal proteins). - A diet with one meat-free dinner a week. - A diet with one meat-free day a week.
Data sources used	Data about the production chains of the protein rich products were obtained from national information guides and databases, the international literature, FAO data on fertilizer use and yields, and directly from food companies. Data from companies were often the only available recent source for information on processed (vegetarian) products. Data on diets from the Dutch food consumption survey (VCP) were used to estimate current animal and vegetable protein consumption.
Mitigation potential	
Direct effects	Reduction potential as compared with current diet: Diet 1 – 1.4 megatonnes CO_2 eq./year. Diet 2 – 6 megatonnes CO_2 eq./year or 3% of Dutch GHG emissions. Diet 3 – 0.6 megatonnes CO_2 eq./year. Diet 4 - 0.5 – 1.1 megatonnes CO_2 cq./year. Additional results: the type of meat also matters. If only chicken meat was consumed, CO_2 emissions would be reduced by 3.5 megatonnes CO_2 eq./year. Replacing meat with dairy products does not generally bring about a reduction.
Indirect effects	Reduced area of land for protein production
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	A reduction in consumption of animal proteins would reduce the area of land needed to produce protein products. An entirely vegan diet, for instance, would reduce the area of land needed to produce protein products by 12,500 km^2/year.
Additional remarks	

B.6 Carlsson-Kanyama, 2008

Carlsson-Kanyama, K. (1998), Climate change and dietary choices - how can emissions of greenhouse gases from food consumption be reduced? Food Policy, Vol. 23 No. 3/4, pp. 277-293	
Description of study	
Description of behavioural mitigation measure (1)	Shift to more sustainable food consumption containing only domestically produced vegetarian food.
Description of BAU scenario applied	No BAU scenario is formulated however it is estimated that currently, food consumption implies the level of about 4 000 kg CO_2 eq. emissions per person per year and exceeds the sustainable GHG emissions level about 4 times. Carlsson-Kanyama defines sustainable consumption patterns according to the following criteria: - Stabilising concentration of CO_2 at 450 ppm by 2100. - Stabilising emissions of CH_4 and N_2O at the level of 1995. - Ensuring that every person living on the Earth until 2100 should have the same rights to emit anthropogenic CO_2 and other GHGs.
Time horizon of the study	Sustainable limits of GHGs are calculated for 1991-2100
Scope of the study	Sweden
Assessment method applied	LCA analysis of production of four food items: pork, dry peas, carrots and rice. These food products are combined in four different meals. Meal *a* was purely vegetarian with ingredients mainly from the domestically produced carrots, potatoes and dry peas (vegetarian-domestic). Meal *b* was also vegetarian but included rice and tomatoes in addition to dry peas (vegetarian-exotic). Meal *c* included rice, tomatoes and pork (animal-exotic), while meal *d* contained only domestically produced food of both animal and vegetable origin (animal-domestic).
Data sources used (selection)	Tables of food energy and nutrients from the Swedish National Food Administration are used together with world population trends data from the United Nations and IPPC data on GHG emissions and recommended future limits.
Mitigation potential	
Direct effects	Switching to food containing only domestically grown vegetables would decrease GHG emissions per capita related to food consumption about 10 times (from about 3,800 kg CO_2 eq. to 420 kg CO_2 eq.) . The mitigation potential should be seen rather as a maximum than a realistic potential.
Indirect effects	No indirect effects are taken into account in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	No specific side-effects were identified and/or quantified in this study
Additional remarks	
Description of behavioural mitigation measure (2)	Shift to more sustainable food consumption containing only domestically produced food including meat products
Description of BAU scenario applied	No BAU scenario is formulated, however it is estimated that currently, food consumption implies the level of about 4,000 kg CO_2 eq. emissions per person per year and exceeds the sustainable GHG emissions level about 4 times. Carlsson-Kanyama defines sustainable consumption patterns according to the following criteria: - Stabilising concentration of CO_2 at 450 ppm by 2100. - Stabilising emissions of CH_4 and N_2O at the level of 1995. - Ensuring that every person living on the Earth until 2100 should have the same rights to emit anthropogenic CO_2 and other GHGs.
Time horizon of the study	Sustainable limits of GHGs are calculated for 1991-2100
Scope of the study	Sweden
Assessment method applied	LCA analysis of production of four food items: pork, dry peas, carrots and rice. These food products are combined in four different meals. Meal *a* was purely vegetarian with ingredients mainly from the domestically produced carrots, potatoes and dry peas (vegetarian-domestic). Meal *b* was also vegetarian but included rice and tomatoes in addition to dry peas (vegetarian-exotic). Meal *c* included rice, tomatoes and pork (animal-exotic), while meal *d* contained only domestically produced food of both animal and vegetable origin (animal-domestic).

Data sources used (selection)	Tables of food energy and nutrients from the Swedish National Food Administration are used together with world population trends data from the United Nations and IPPC data on GHG emissions and recommended future limits.
Mitigation potential	
Direct effects	Assuming that currently, food consumption implies the level of about 4,000 kg CO_2 eq. emissions per person per year and exceeds the sustainable GHG emissions level about 4 times, switching to food containing domestically grown vegetables and meat would decrease the GHG emissions per capita about 4.5 times (from about 3,800 to 830 kg CO_2 eq.). The mitigation potential should be seen rather as a maximum than a realistic potential.
Indirect effects	No indirect effects are taken into account in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	No specific side-effects were identified and/or quantified in this study
Additional remarks	

B.7 CE and Blonk Milieu Advies, 2010

CE and Blonk Milieu Advies (2010), Milieuanalyses Voedsel and Voedselverliezen. Ten behoeve van prioritaire stromen ketengericht afvalbeleid, Delft (Environmental analysis of food and food waste. LCA-based guidelines for waste management)	
Description of study	
Description of behavioural mitigation measures (1)	Reducing food waste
Description of BAU scenario applied	Current situation regarding food consumption and wastage is estimated for 2010 based on available data sources. Food products have been divided in three categories: products with low value, products with medium value and products with high value. The respective percentage of food left on the plate was estimated for these categories as follows: 10%, 7.5% and 5%.
Time horizon of the study	2010-2015
Scope of the study	The Netherlands
Assessment method applied	LCA analysis with the use of the ReCiPe factors
Data sources used (selection)	Food consumption surveys giving the estimates of food actually consumed and statistics from the National Statistics Office (CBS) reflecting the food purchased. Estimates of unavoidable waste (inedible food fractions) and avoidable waste (food that is thrown to garbage) are taken from literature, including the following sources: - Milieu Centraal (2007), Verspilling en indirecte energie van voeding, Utrecht : Milieu Centraal, 2007. - WUR (2007), D. Stegeman, Inbakverlies biologisch varkensvlees, Wageningen : AFSG Wageningen UR, 2007. - WRAP (2008), Lorrayne Ventour, The food we waste, Banbury : WRAP, 2008. - Faostat and Eurostat statistics are used for data on agriculture.
Mitigation potential	
Direct effects	Reducing food waste by 20% (including packaging) would lower environmental burden of food by 3.5%. Reducing all food waste would lower environmental burden of food by 15.5%. Reducing food waste by 22% of weight at home and 40% outside home would lower environmental burden of food by 5.5%. No specific climate change mitigation potential numbers are given but these can be obtained from the data available at CE Delft.
Indirect effects	No specific indirect effects were identified and/or quantified in this study.
Rebound effects	No rebound effects are taken into account in this study.
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study.
Side-effects included	Reducing food waste would contribute not only to climate change mitigation but would have influence on all the categories of impact. These are included in the indicator but the change in

	impact is not estimated separately. These other impacts are: ozone depletion, terrestrial acidification, freshwater and marine eutrophication, human toxicity, photochemical oxidant formation, particular matter formation, terrestrial and water ecotoxicity, ionising radiation, land-use, water depletion, mineral depletion, fossil depletion. These impacts are, however, not quantified.
Additional remarks	
Description of behavioural mitigation measure (2)	Shift to more sustainable food consumption – various types of diets are evaluated
Description of BAU scenario applied	Reference diet is assessed based on food consumption surveys giving the estimates of food actually consumed and statistics from the National Statistics Office (CBS) reflecting the food purchased.
Time horizon of the study	2010-2015
Scope of the study	The Netherlands
Assessment method applied	LCA analysis with the use of the ReCiPe factors
Data sources used (selection)	Data on various diets are taken from: Blonk et al. (2008), Milieueffecten van Nederlandse consumptie van eiwitrijke producten: Gevolgen van vervanging van dierlijke eiwitten anno 2008, Gouda: Blonk Milieu Advies, 2008.
Mitigation potential	
Direct effects	Theoretic shift of the whole population to a so-called Willett-diet, with reduced consumption of meat, fish and eggs, could reduce environmental impact of food by 25% (with 10% of the population shifting, 2.5% reduction could be achieved). Reduction in animal protein consumption (cutting beef and pork consumption by about half) by all population would lead to about 13% reduction of environmental burden while participation of 10% of the population would translate into only about 1% reduction in burden. Also doubling the number of vegetarians would contribute to reduction of the environmental burden of food by only about 1%. No specific climate change mitigation potential numbers are given but these can be obtained from the data available at CE Delft.
Indirect effects	No specific indirect effects were identified and/or quantified in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	Changing diet would contribute not only to climate change mitigation but would have impact on all the categories of impact. These are included in the indicator but the change in impact is not estimated separately. These other impacts are: ozone depletion, terrestrial acidification, freshwater and marine eutrophication, human toxicity, photochemical oxidant formation, particular matter formation, terrestrial and water ecotoxicity, ionising radiation, land-use, water depletion, mineral depletion, fossil depletion. These impacts are, however, not quantified.
Additional remarks	
Description of behavioural mitigation measure (3)	Shifting from Brazilian beef to Irish beef
Description of BAU scenario applied	Beef from Brazil is estimated to contribute to about 15% of environmental burden related to food consumed at home and to about 12% of environmental burden related to food consumed outside home
Time horizon of the study	2010-2015
Scope of the study	The Netherlands
Assessment method applied	LCA analysis with the use of the ReCiPe factors
Data sources used (selection)	The differences in environmental impacts between beef from Brazil and beef from Ireland are assessed using the LCA method. Regarding climate change impact, the ReCiPe factor for Brazilian beef is equal to 60 kg of CO_2 eq. while the relevant score for Irish beef equals 37 kg of CO_2 eq.
Mitigation potential	
Direct effects	Replacing all beef imported from Brazil with beef from Ireland would reduce environmental burden of food by about 10% (however with the use of another, more conservative study, this reduction would be much lower and equal to about 5%). No specific climate change mitigation potential numbers are given but these can be obtained from the data available at CE Delft.

Indirect effects	No specific indirect effects were identified and/or quantified in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	Replacing Brazilian beef with Irish beef would contribute not only to climate change mitigation but would have impact on all the categories of impact. These are included in the indicator but the change in impact is not estimated separately. These other impacts are: ozone depletion, terrestrial acidification, freshwater and marine eutrophication, human toxicity, photochemical oxidant formation, particular matter formation, terrestrial and water ecotoxicity, ionising radiation, land-use, water depletion, mineral depletion, fossil depletion. These impacts are, however, not quantified.
Additional remarks	

B.8 Dutilh et al., 2000

Dutilh, C.E. and Kramer, K.J. (2000), Energy Consumption in the Food Chain. Comparing alternative measures in food production and consumption. Ambio Vol. 29 No 2	
Description of study	
Description of behavioural mitigation measure	Reducing energy intensity of food would lead to CO_2 mitigation. Energy intensity factors of various food categories and processing/transport measures are given. From these numbers it can be concluded that shifting to a diet with less meat content and with higher share of locally produced products would be beneficial for the environment by implying less energy requirement.
Description of BAU scenario applied	No specific BAU is described in this study
Time horizon of the study	No specific time horizon is taken in this study; data on energy use comes from 1994
Scope of the study	The Netherlands
Assessment method applied	Literature review
Data sources used (selection)	Kramer, K.J., Biesiot, W., Kok., R., Wilting, H.C. and Schoot Uiterkamp, A.J.M. (1994), *Energy counts. Possible energy savings of household spendings*. IVEM-research report no. 71. Centre for Energy and Environmental Studies, University of Groningen, The Netherlands. (In Dutch, summary in English) 84 pp. Kramer, K.J. and Moll, H.C. (1995), *Energie voedt. Nadere analyses van het indirecte energieverbruik van voeding*. IVEM-onderzoeksrapport no. 77. Centre for Energy and Environmental Studies, University of Groningen, The Netherlands (In Dutch, summary in English). 204 pp. V.d. Berg, N., Huppes, G. and v.d. Ven, B.L. (1995), *Milieuanalyses NPF*, Study by Netherlands Organisation for Applied Scientific Research (TNO) and Centre for Environment, University of Leiden (CML), ref nr R95-278, The Netherlands (In Dutch), 34 pp. Kramer, K.J. (1996), *Energy Consumption in Food Products Life Cycles*. In: Proc. International Conference of Life Cycle Assessment in Agriculture, Food, Non-Food Agro-Industry and Forestry: Achievements and Prospects. Ceuterick, D. Flemish Instute for Technology Research (VITO), Mol, Belgium. pp. 289–293.
Mitigation potential	
Direct effects	No CO_2 reduction potential was estimated
Indirect effects	No indirect effects are taken into account in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	No side-effects are included in this study
Additional remarks	

B.9 Kool et al., 2010

Kool, A., Blonk, H., Ponsioen, T., Sukkel, W., Vermeer, H., De Vries, J., & Hoste, R. (2010), Carbon footprints of conventional and organic pork: Assessments of typical production systems in the Netherlands, Denmark, England and Germany	
Description of study	
Description of behavioural mitigation measure	Production of pork, conventional and organic
Description of BAU scenario applied	No BAU scenario was applied. CO_2 emissions that are associated with current pork production practices were estimated.
Time horizon of the study	No time horizon is mentioned
Scope of the study	The Netherlands, Denmark, England, Germany
Assessment method applied	Life Cycle Analyses were used to estimate the contribution of a products' lifecycle to environmental indicators, such as greenhouse gas emissions. All emissions that are associated with the production process up to and including the slaughterhouse were included. Emissions as a result of cooling and transport after the slaughterhouse were not taken into account.
Data sources used	IPCC guidelines for performing national inventories on greenhouse gasses were used. In the present study the guidelines of 2006 were used.
Mitigation potential	
Direct effects	The carbon footprint of conventional pork was estimated between 3.5 and 3.7 and 3.7 kg CO_2 eq. per kg pork. This did not differ between countries. The carbon footprint of organic pork was estimated between 4.0 and 5.0 kg CO_2 eq. per kg pork. Production of feed (crop growing, transport of crop products, processing crop products, transport of raw materials and feed mixing) contributes roughly 50-60% to the carbon footprints of conventional and organic pork. For most systems, the second most important source is methane emissions from manure storage (12-17%).In systems with a substantial share of grazing (organic systems in Denmark and England), the emissions from grazing are the second most important source. Several reduction measures are identified, but no quantitative assessments of reduction potential is given: - Better feed composition can reduce CO_2 emissions by 5-7.5%. - Better feed use can reduce CO_2 emissions by 10%. - Using wet co-products as feed can reduce CO_2 emissions by 10% on the condition that these products are produced nearby. - Storage of manure. - Digestions of manure.
Indirect effects	No indirect effects are taken into account in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	No specific side-effects were identified and/or quantified in this study
Additional remarks	

B.10 Kramer et al., 1999

Kramer et al. (1999), Greenhouse gas emissions related to Dutch food consumption. Energy Policy 27, 203-216	
Description of study	
Description of behavioural mitigation measure (1)	Shift from food products with higher GHG intensity to food products with lower GHG intensity. The paper gives estimates of GHG intensity factors per Dutch guilder spent annually by an average household on various food items.
Description of BAU scenario applied	No specific BAU is described in this study; the paper gives a summary of expenditures of an average Dutch household on various types of food together with their GHG intensity.
Time horizon of the study	No specific time horizon is taken in this study. Data on food expenditures and GHG intensity is for 1990.
Scope of the study	The Netherlands
Assessment method applied	Quantitative analysis using Energy Analysis Program
Data sources used	CBS (the main Dutch statistics office) statistics are used for the data on expenditures
Mitigation potential	
Direct effects	No CO_2 reduction potential was estimated
Indirect effects	No indirect effects are taken into account in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	While substituting various food products, care should be given to nutritional value of the substitutes
Additional remarks	

B.11 Pimentel et al., 2008

Pimentel et al. (2008), Reducing Energy Inputs in the US Food system, Hum Ecol 28 36: 459-471	
Description of study	
Description of behavioural mitigation measure (1)	Reducing calories intake from food. Reduction of the American average daily calories intake by one-third would bring the daily intake to the level recommended by the Food and Drug Administration (FDA), that is 2,000–2,500 kcal per day.
Description of BAU scenario applied	Currently, Americans consume on average about 3,747 kcal per day, which is exceeding the recommended levels
Time horizon of the study	No specific time horizon; data on calories intake from 2004
Scope of the study	USA
Assessment method applied	Literature review using data on the average daily intake of kcal, looking for measures of lowering energy requirement in food production chains. Changing the diet is one of the measures; the authors devote much space to various technical measures such as converting to renewable energy sources, improving transport and packaging processes – however these are not relevant for the topic of behavioural mitigation measures.
Data sources used	FAOSTAT statistics are used to show the breakdown of the current American diet and the proposed reduction
Mitigation potential	
Direct effects	No CO_2 reduction potential was estimated. However, mitigation potential within the food system due to consumption reduction would be equal to the calories intake reduction, assuming the same structure of the average diet.
Indirect effects	No indirect effects are taken into account in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	No specific side-effects were identified and/or quantified in this study.

Additional remarks	
Description of behavioural mitigation measure (2)	Vegetarian diet. Such type of diet implies about 33% less energy needed for food production.
Description of BAU scenario applied	Currently, meat constitutes about 14% of the caloric intake of an average American but it contributes to about 50% of energy needed to produce all food.
Time horizon of the study	No specific time horizon; data on calories intake from 2004.
Scope of the study	USA
Assessment method applied	Literature review, data from the US Department of Agriculture
Data sources used	
Mitigation potential	
Direct effects	No CO_2 reduction potential was estimated. The percentage cut in energy consumption is not equal to the percentage cut in CO_2 eq. emissions because in agriculture, non- CO_2 GHG emissions play an important role.
Indirect effects	No indirect effects are taken into account in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	No specific side-effects were identified and/or quantified in this study
Additional remarks	
Description of behavioural mitigation measure (3)	Reduction of junk food intake. It is estimated that cutting junk food intake from 33 to 10% would reduce daily average calories intake from 3,747 to 2,826 kcal
Description of BAU scenario applied	Currently junk food intake in the US is estimated at about 33%.
Time horizon of the study	No specific time horizon; data on calories intake from 2004
Scope of the study	USA
Assessment method applied	Literature review
Data sources used	FAOSTAT statistics and scientific literature
Mitigation potential	
Direct effects	No CO_2 reduction potential was estimated
Indirect effects	Health improvements
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	No specific side-effects were identified and/or quantified in this study
Additional remarks	

B.12 Popp et al., 2010

Popp, A., Lotze-Campen, H., Bodirsky, B. (2010), Food consumption, diet shifts and associated non- CO_2 greenhouse gases from agricultural production, Global Environmental Change 20, 451-462	
Description of study	
Description of behavioural mitigation measure (1)	Reduction in demand for meat products by 25% per decade. Production of meat is on average related to much higher non- CO_2 GHG emission rates than production of other food types thus lowering dietary content of meat would offer quite large mitigation potential. The first measure assessed in the study does not include additional technological improvements.
Description of BAU scenario applied	The baseline scenario is with constant share of animal products in human diets. In this scenario, global agricultural non-CO_2 emissions are predicted to increase from 5,314 Mt CO_2 eq. in 1995 to 8 690 Mt CO_2 eq. in 2055.
Time horizon of the study	1995-2055
Scope of the study	Global
Assessment method applied	MAgPIE model. This is a land-use model coupled with a grid-based dynamic vegetation model, where economic data is combined with data on land and water constraints and potential crop yields. In modelling, the authors focused on N_2O emissions from the soil and manure storage as well as on CH_4 emissions from rice cultivation, enteric fermentation and manure storage that constitute almost 90% of total agricultural emissions of GHGs.
Data sources used (selection)	FAOSTAT statistics are used for consumption patterns around the globe, World Bank and CIESIN statistics are used for population indicators. The model uses also US-EPA statistics on global anthropogenic non- CO_2 greenhouse gas emissions.
Mitigation potential	
Direct effects	Reduction in demand for meat products by 25% per decade would lower non- CO_2 GHG emissions from agriculture by 51% as compared to the baseline scenario in 2055
Indirect effects	No specific indirect effects are taken into account in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	Possible negative effects of shifting away from meat are mentioned: – meat is a good source of protein, which is important especially in poor countries, negative health effects could follow after reduction of dietary meat content; – reducing meat consumption might put more stress on fish resources, which are already not in a good condition in many parts of the World. – GDP related to livestock currently accounts for about 40% of agricultural GDP. Reducing this sector might put in risk the main source of income for many people.
Additional remarks	
Description of behavioural mitigation measure (2)	Reduction in demand for meat products. Production of meat is on average related to much higher non-CO2 GHG emission rates than production of other food types thus lowering dietary content of meat would offer quite large mitigation potential. The second measure assessed in the study include additional technological improvements in the food production chain such as better water management especially during rice production, better manure management (better coverage, biogas plants), improved N efficiency while using fertilizers, and better livestock quality and management.
Description of BAU scenario applied	The baseline scenario was assumed with constant share of animal products in human diets. In this scenario, global agricultural non-CO2 emissions are predicted to increase from 5 314 CO_2 eq. in 1995 to 8 690 CO_2 eq. in 2055.
Time horizon of the study	1995-2055
Scope of the study	Global
Assessment method applied	MAgPIE model. This is a land-use model coupled with a grid-based dynamic vegetation model, where economic data is combined with data on land and water constraints and potential crop yields. In modelling, the authors focused on N2O emissions from the soil and manure storage as well as on CH4 emissions from rice cultivation, enteric fermentation and manure storage that constitute almost 90% of total agricultural emissions of GHGs.

Data sources used (selection)	FAOSTAT statistics are used for consumption patterns around the globe, World Bank and CIESIN statistics are used for population indicators. The model uses also US-EPA statistics on global anthropogenic non-CO_2 greenhouse gas emissions.
Mitigation potential	
Direct effects	Reduction in demand for meat products by 25% per decade with additional technological mitigation measures would lower non-CO2 GHG emissions from agriculture by about 70% in 2055 as compared to the baseline scenario.
Indirect effects	Possible negative effects of shifting away from meat are mentioned: - Meat is a good source of protein, which is important especially in poor countries; negative health effects could follow after reduction of dietary meat content. - Reducing meat consumption might put more stress on fish resources, which are already not in a good condition in many parts of the World. - GDP related to livestock currently accounts for about 40% of agricultural GDP. Reducing this sector might put in risk the main source of income for many people.
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	No specific side-effects were identified and/or quantified in this study
Additional remarks	

B.13 Stehfest et al., 2009

Stehfest, E., Bouwman, L., Van Vuuren, D. P., Den Elzen, M. G. J., Eickhout, B., & Kabat, P. (2009), Climate benefits of changing diet	
Description of study	
Description of behavioural mitigation measure	Change to a low animal protein diet. Four different diets have been defined: no ruminant meat, no meat, no animal products and a healthy diet (Willet).
Description of BAU scenario applied	In the BAU scenario, a possible future is portrayed with default assumptions on meat consumption (i.e., an income-driven increase in per capita meat consumption), and no climate policy.
Time horizon of the study	Present-2050
Scope of the study	Worldwide
Assessment method applied	An integrated assessment model (IMAGE) was used to explore the long-term dynamics of global change as a function of drivers such as demographic and economic development. In order to explore the impact of dietary transitions, four variants of the BAU scenario were developed with partial or complete substitution of meat by plant proteins. These four variants are (a) complete substitution of meat from ruminants (NoRM), (b) complete substitution of all meat (NoM), (c) complete substitution of all animal products (meat, dairy products and eggs) (NoAP) and finally (d) partial substitution of meat based on a healthy diet variant (*HealthyDiet*, HDiet).
Data sources used	Greenhouse gas emissions are mainly computed on the basis of guidelines of the Intergovernmental Panel on Climate Change. For agricultural production, the IMAGE model was calibrated to follow the projections of the FAO for 2000-2050.
Mitigation potential	
Direct effects	The healthy diet results in a reduction of GHG emissions of 10% as compared with the BAU scenario and a vegan diet results in about 17% reduction (the reductions refer to cumulative emissions between 2010 and 2050).
Indirect effects	Due to the reduced greenhouse gas emissions and concentrations, the remaining emission reductions required to meet the emission profile of the 450 ppm CO_2 eq. scenario are 31–47% lower in the dietary variants compared to the reference case. Therefore, less emission reduction is needed in the energy sector. As a result, the carbon price required to induce changes shows a slower increase over time, as less emission reduction is required to achieve the stabilisation targets. Consequently, the mitigation costs are much lower than under the reference case. The overall net present value of mitigation costs over the 2000–2050 period in both no ruminant meat and no meat scenarios are reduced by 70% compared to the reference case (0.3% of GDP and not 1%).
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	A reduction in animal proteins also results in a dramatic decrease in land-use. The strongest impacts occurs for pasture area, which is reduced by 80% or 2,700 Mha (in no ruminant meat and in no meat scenarios) and by 100% or 3,200 Mha (in no animal protein scenario) compared to the reference scenario. In all three variants there is a reduction of the global cropland area. The reductions amount to 6% in the no ruminant meat variant, as the arable area required for crops to feed ruminants exceeds the area for producing plant proteins. A further decrease (4%) in global crop area occurs when all meat is substituted by plant proteins in the no meat variant. The additional substitution of milk and eggs by plant proteins in no animal protein leads to complete abandonment of pasture and a small increase in the global cropland area. More land is available for e.g. energy crops production.
Additional remarks	

B.14 Sukkel et al., 2010

Sukkel, W., Stilma, E., & Jansma, J. E. (2010), Verkenning van de milieueffecten van lokale productie en distributie in Almere (Exploration of the environmental effects of local production and distribution in Almere)	
Description of study	
Description of behavioural mitigation measure	Local production of food, plus use of renewable energy for production and distribution
Description of BAU scenario applied	In the BAU scenario, no local food production and no changes in the use of renewable energy for production and distribution is projected. This is compared with Scenario 1, in which 20% of food is produced locally and 20% of energy for production and distribution is renewable, and Scenario 2, in which 20% of food is produced locally and organically, and 100% of energy for production and distribution is renewable.
Time horizon of the study	The scenarios are estimated for the year 2030. However, for a number of variables, estimations are used which are reliable for the next 10 years.
Scope of the study	The geographical scope of the study is the city of Almere in the Netherlands. It is assumed that Almere will have 350,000 inhabitants in ten years, versus 188,000 now.
Assessment method applied	Life Cycle Analyses were used to estimate energy use, GHG emissions and food kilometres. Based on data on consumer spending on food and food consumption, the average food consumption for all inhabitants is estimated. Next, land-use, food kilometres, fossil fuel use and carbon food print that are associated with this estimation of food consumption are calculated. This is the BAU scenario. For Scenario 1, these numbers are again calculated for a situation in which 20% of food consumed is produced locally and 20% of energy used is renewable. For Scenario 2, these estimates are again calculated for a situation in which 20% of food is produced locally and organically, and 100% of energy for production and distribution is renewable.
Data sources used	Food consumption: RIVM Food Consumption Survey (VCP: Voedsel consumptive peiling) Land-use: KWIN (2006) Energy use: Bos et al. (2007)
Mitigation potential	
Direct effects	Results show that a percentage of locally produced foods of 19% is feasible. In Scenario 1, this percentage of locally produced foods in 2030 will lead to a reduction of 9,433 ton CO_2 emission per year as compared with the BAU scenario. In Scenario 2, this percentage of locally produced foods in 2030 will lead to a reduction of 27,100 ton CO_2 emission per year as compared with the BAU scenario. In the BAU scenario, a major part of energy use takes place in the primary production process. The reductions in the use of fossil fuels is mainly the result of the assumptions of renewable energy use in Scenario 1 and 2. Transport kilometres are responsible for a very small part of reductions in energy use, since many products that are produced locally in Scenario 1 and 2 are already produced in the Netherlands in the BAU.
Indirect effects	No indirect effects are taken into account in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	No specific side-effects were identified and/or quantified in this study
Additional remarks	

B.15 Tukker et al. (2009)

Tukker, A., Bausch-Goldbohm, S., Verheijden, M., De Koning, A., Kleijn, R., Wolf, O., & Perez Domingeuz, I. (2009), Environmental impacts of diet changes in the EU	
Description of study	
Description of behavioural mitigation option	Diets in line with recommendations for healthy living
Description of BAU scenario applied	In the BAU scenario, a continuation of dietary habits in the EU-27 is assumed
Time horizon of the study	Calculations are based on current dietary habits. No timeline is given
Scope of the study	EU-27
Assessment method applied	The environmental impact of the existing diets and the three alternative scenarios were assessed with the E3IOT model. An overall environmental impact measure was used as the main measure of interest. GHG emissions and resource use were combined to create this measure. Three scenarios were estimated. Scenario 1: healthy diet (increase in fruit and vegetable); Scenario 2: healthy diet + (including recommendations to reduce intake of meat); Scenario 3: Mediterranean diet (plant-centred, containing relatively large shares of fruit, vegetable, whole grains, fish, and olive oil).
Data sources used	The FAO food balance sheets were used to estimate current dietary patterns in the EU-27
Mitigation potential	
Direct effects	Results show that Scenario 1 did not result in a reduction in environmental impact, since it mainly focuses on increasing fruit and vegetable intake. In Scenario 2 and 3, the environmental impacts related to food consumption decreased from 27 to 25% out of all impacts related to final consumption I the EU-27. This 2% reduction corresponds to a reduction of the impacts related to food consumption of around 8%. It has to be kept in mind that this substantial reduction bases on the change to diets with only moderate changes in the share of meat consumption.
Indirect effects	No indirect effects are taken into account in this study
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	No specific side-effects were identified and/or quantified in this study
Additional remarks	

B.16 Weidema et al., 2008

Weidema, B.P., Wesnaes, M., Hermansen, J., Kristensen, T., Halberg, N. (2008), Environmental Improvement Potentials of Meat and Dairy Products, JRC (IMPRO Study)	
Description of study	
Description of behavioural mitigation measure (1)	Increasing the rate of delivery services for groceries so that 25% of consumers' trips for shopping of groceries are replaced with home delivery
Description of BAU scenario applied	Consumption of meat and dairy products in EU-27 is estimated for 2004 so this point can be regarded as BAU
Time horizon of the study	No specific time horizon for this measure is given
Scope of the study	EU-27
Assessment method applied	Hybrid life cycle assessment method, a system model that combines the top-down input-output matrices based on national accounting statistics and national emission statistics (NAMEA matrices) with the detailed modelling of bottom-up processes from process-based life cycle assessments. To represent the livestock production in a way that allows to model different improvement measures, a range of production systems were modelled, based on well-documented biological input-output relations. These production systems have been scaled to the level of EU-27, and fitted to the production volume, area and number of livestock given by Faostat. Among the processes included in the model there are 15 agricultural processes, 20 food and feed industry sectors, 4 household processes and 7 waste management processes.
Data sources used	Input-output matrices NAMEA, combining national accounting statistics with national emission statistics.
Mitigation potential	
Direct effects	Global warming reduction potential of this measure amounts to 12.4 Mt of CO_2 eq. annually, or 1.86% of the total impact of food in the global warming midpoint category. Because these numbers refer to all food products, the relevant reduction to include only meat and dairy products is applied (equal to 42%) so that a reduction of 0.78% is achieved in meat and dairy impact category. This number includes also the upstream process such as car manufacture but it does not include the fact that emissions from car driving are larger for short trips with cold engine than for longer trips (with a delivery van), which means that the reduction potential could be larger.
Indirect effects	Time saving related to less trips for groceries was estimated in this measure at the level of 25% of the time spent while shopping for groceries. Applying 9.5 Euro valuation of an hour of time (half of the average wage), 65 Euro per capita per year could be saved, or 31 billion Euro for EU-27. Also, reduction in retail space could be obtained, as warehouses could replace some shops.
Rebound effects	Rebound effects related to increased home delivery rates include additional road space which may reduce congestion but at the same time induce increased traffic (because of less congestion).
Costs and side-effects	
Cost estimates	The costs of delivery service are set at 3.99 Euro per delivery. The corresponding saved costs for private transport amount to 1.03 Euro per delivery. With an expected 23 deliveries per capita per year, this amounts to an additional cost of 33 billion Euro per year of which 42%, or 14 billion Euro, is linked to the consumption of meat and dairy products in EU-27.
Side-effects included	If home delivery of groceries were to include ready-made meals, some households could consider smaller dwelling with less kitchen space. Also a lower rate of car ownership could be expected where a car is primarily needed for shopping. This measure would also trigger mitigation of other environmental impacts (in addition to global warming) such as land-use, eutrophication, ozone depletion, ecotoxicity, etc.
Additional remarks	
Description of behavioural mitigation measure (2)	Replacement of cold appliances with new A+/A++ appliances and preventing consumers from buying other than new A+/A++ appliances
Description of BAU scenario applied	
Time horizon of the study	2009-2013

Scope of the study	EU-27
Assessment method applied	Hybrid life cycle assessment method, a system model that combines the top-down input-output matrices based on national accounting statistics and national emission statistics (NAMEA matrices) with the detailed modelling of bottom-up processes from process-based life cycle assessments. To represent the livestock production in a way that allows to model different improvement measures, a range of production systems were modelled, based on well-documented biological input-output relations. These production systems have been scaled to the level of EU-27, and fitted to the production volume, area and number of livestock given by Faostat. Among the processes included in the model there are 15 agricultural processes, 20 food and feed industry sectors, 4 household processes and 7 waste management processes.
Data sources used	Input-output matrices NAMEA, combining national accounting statistics with national emission statistics
Mitigation potential	
Direct effects	The average annual net improvement potential is calculated over the period 2010 to 2040 as accumulated electricity saving of 340 kWh per 100 litres. Improvement potential in the category of global warming has been estimated at the level of 6.59 Mt of CO_2 eq. annually. This number refers however not only to meat and dairy products, if we want to account for this fact, the improvement potential has to be multiplied by 42%, which would result in 2.35 Mt of CO_2 eq.
Indirect effects	No specific indirect effects are taken into account for this measure
Rebound effects	No rebound effects are taken into account for this measure
Costs and side-effects	
Cost estimates	Additional annual production costs to achieve electricity saving have been estimated at 252 million Euro while saving on electricity costs – at the level of 595 million Euro. This gives an undiscounted net annual saving of 343 million Euro for EU-27, of which 42% can be ascribed to meat and dairy products.
Side-effects included	This measure would also trigger mitigation of other environmental impacts (in addition to global warming) such as land-use, eutrophication, ozone depletion, ecotoxicity, etc.
Additional remarks	
It should be noted that public economic support would be needed for such a scheme at least in case of appliances from the period 1996-2000, as the monthly savings on energy costs, estimated at 3.15 Euro, would not be attractive enough. The consumer would also need compensation for the fact that the new appliances would have to be replaced earlier than in case if the existing appliances were kept.	
Description of behavioural mitigation measure (3)	Better planning of food purchases. It is estimated that food loss can be halved by application of better planning tools, and that these tools will be accepted by 25% of consumers, resulting in an average 12.5% reduction in food waste, or 2.5% of the total amount of meat and dairy products purchased by households.
Description of BAU scenario applied	Losses of meat and dairy products in households are estimated at about 20%
Time horizon of the study	No specific time horizon; changes in annual patterns are considered
Scope of the study	EU-27
Assessment method applied	Hybrid life cycle assessment method, a system model that combines the top-down input-output matrices based on national accounting statistics and national emission statistics (NAMEA matrices) with the detailed modelling of bottom-up processes from process-based life cycle assessments. To represent the livestock production in a way that allows to model different improvement measures, a range of production systems were modelled, based on well-documented biological input-output relations. These production systems have been scaled to the level of EU-27, and fitted to the production volume, area and number of livestock given by Faostat. Among the processes included in the model there are 15 agricultural processes, 20 food and feed industry sectors, 4 household processes and 7 waste management processes.
Data sources used	Input-output matrices NAMEA, combining national accounting statistics with national emission statistics. Additional data sources include the following literature sources: Huang, A., Barzi, F., Huxley, R., Denyer, G., Rohrlach, B., Jayne, K., Neal, B. (2006), The Effects on Saturated Fat Purchases of Providing Internet Shoppers with Purchase-Specific Dietary Advice: A Randomised Trial, Plos Clinical Trials 1 (5). Mathers, C.D., Bernard, C., Iburg, K.M., Inoue, M., Fat, D.M., Shibuya, K., Stein, C., Tomijma, N., Xu H. (2004), Global Burden of Disease in 2002: data sources, methods and results. Genevea: World Health Organisation, Global Programme on Evidence for Health Policy Discussion

	Paper No 54 with accompanying spreadsheets (revised February 2004)
Mitigation potential	
Direct effects	CO_2 eq. reduction potential was estimated at the level of 11.7 Mt annually, or 1.75% decrease of total impact of meat and dairy products in the global warming impact category
Indirect effects	It can be noted that there is a mutual synergy between the measure of home delivery of groceries and the measure of better household planning. Both measures require a more structured shopping behaviour, such as Internet-shopping, and facilitate the correspondence between planned meals and items purchased.
Rebound effects	No rebound effects are taken into account in this measure
Costs and side-effects	
Cost estimates	Saving food from being wasted would lead to a cost saving of about 6,800 million annually, with about 1% being from saved waste treatment.
Side-effects included	Better meal planning can be expected to stimulate a more healthy composition of meals in general. A conservative assumption that the 9% change in purchase behaviour in the trial of Huang et al. (2006) will be reflected in a 9% decrease in dietary related morbidity and mortality allows to estimate the total annual potential health effects of meal planning tools based on Mathers et al. (2004) at the level of 640 000 QALY. This measure would also trigger mitigation of other environmental impacts (in addition to global warming) such as land-use, eutrophication, ozone depletion, ecotoxicity, etc.
Additional remarks	
Better planning would also contribute to increased security of supply of food in households – these effects however have not been quantified.	

B.17 Winter et al., 2008

Winter et al. (2008), Creating green consumer loyalty. How to strategically market CSR and obtain consumer preference	
Description of study	
Description of behavioural mitigation measure (1)	Corporate social responsibility (CSR) initiatives. CSR programmes can be aimed at environmental performance but they may also focus on other aspects including community support, diversity, personnel policy and foreign activities. CSR may be rewarded by client loyalty and repeated purchases, however it seems that while the customers in principle support such actions, the real reward for the companies which engage in such actions is relatively weak.
Description of BAU scenario applied	No specific BAU is described in this study
Time horizon of the study	No specific time horizon is taken in this study
Scope of the study	Europe
Assessment method applied	Literature review showing the mechanisms why and how the firms engage in CSR programmes and how such programmes are perceived by the consumers
Data sources used (selection)	Creyer, E.H., and Ross Jr, W.T. (1997), 'The influence of firm behaviour on purchase intention: do consumers really care about business ethics?' In: Journal of Consumer Marketing, 14(6), 421-432. Ellen, P.S., Webb, D.J., and Mohr, L.A. (2006), 'Building Corporate Associations: Consumer Attributions for Corporate Socially Responsible Programs.' In: Journal of the Academy of Marketing Science, 34(2), 147-157. Sen, S., Bhattacharya, C.B., and Korschun, D. (2006), 'The Role of Corporate Social Responsibility in Strengthening Multiple Stakeholder Relationships: A Field Experiment. 'In: Journal of the Academy of Marketing Science, 34(2), 158-166.
Mitigation potential	
Direct effects	No CO_2 reduction potential was estimated
Indirect effects	Indirect effects include creating a better image and, consequently, a better competitive position at the market for the companies engaging in the CSR initiatives
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	No specific side-effects were identified and/or quantified in this study
Additional remarks	
Description of behavioural mitigation measure (2)	Labelling. Various types of labelling are distinguished. The authors find that the biggest market opportunities for sustainable positioning lie in the combination of values, whether social (such as environmental-friendliness) and personal (such as health, taste and quality) or functional and emotional.
Description of BAU scenario applied	No specific BAU is described in this study
Time horizon of the study	No specific time horizon is taken in this study
Scope of the study	Europe
Assessment method applied	Literature review showing the mechanisms why and how the firms use labelling and how it is perceived by the consumers.
Data sources used (selection)	Davis, J.J. (1993), 'Strategies for environmental advertising.' In: Journal of Consumer Marketing, 10(2), 1936. Chernatony de, L., Harris, F., and Dall'Olmo Riley, F. (2000), 'Added value: its nature, roles and sustainability.' In: European Journal of Marketing, 34(1/2), 39-56. Bakker de, E., Backus, G., Selnes, T., Meeusen, M., Ingenbleek, P., and Van Wagenberg, C. (2007), Nieuwe rollen, nieuwe kansen? Een programmeringsstudie voor toezicht op controle in het agrofoodcomplex. Rapport 6.07.08. LEI: Den Haag. Aaker, D.A. (1991), Managing Brand Equity: Capitalizing on the Value of a Brand Name. The Free Press, New York. Kotler, P. (2003), Principes van marketing. Pearson Prentice Hall/Pearson Education Benelux, Amsterdam.

	Meeusen, M.J.G., and Deneux, S.D.C. (2002), Een Babylonische keurmerkverwarring?; Een studie naar de verwarring onder ketenactoren over keurmerken op voedingsmiddelen. Den Haag, LEI, Rapport 5.02.06.
Mitigation potential	
Direct effects	No CO_2 reduction potential was estimated
Indirect effects	Indirect effects include creating a better image and, consequently, a better competitive position at the market for the companies engaging in the CSR initiatives
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	No specific side-effects were identified and/or quantified in this study
Additional remarks	
Description of behavioural mitigation measure (3)	Branding – creating a strong, recognisable brand which would be associated with, for example, environmental care or sustainability. The most effective brand strategy would be green positioning centred in the creation of emotional benefits sustained by information on environmentally sound functional attributes.
Description of BAU scenario applied	No specific BAU is described in this study
Time horizon of the study	No specific time horizon is taken in this study
Scope of the study	Europe
Assessment method applied	Literature review showing the mechanisms why and how the firms use branding policies and how it is perceived by the consumers
Data sources used (selection)	Brown, T.J., and Dacin, P.A. (1997), 'The Company and the Product: Corporate Associations and Consumer Product Responses.' In: Journal of Marketing, 61(1), 68-84. Berens, G., van Riel, C.B.M., and van Bruggen, G.H. (2005), 'Corporate Associations and Consumer Product Responses: The Moderating Role of Corporate Brand Dominance.' In: Journal of Marketing, 69(3), 35-48. Keller, K.L., and Aaker, D.A. (1993), 'The Effects of Sequential Introduction of Brand Extensions.' In: Journal of Marketing Research, 29(1), 35-50. Kotler, P. (2003), Principes van marketing. Pearson Prentice Hall/Pearson Education Benelux, Amsterdam.
Mitigation potential	
Direct effects	No CO_2 reduction potential was estimated
Indirect effects	Indirect effects include creating a better image and, consequently, a better competitive position at the market for the companies engaging in the CSR initiatives
Rebound effects	No rebound effects are taken into account in this study
Costs and side-effects	
Cost estimates	No cost estimates were presented in this study
Side-effects included	No specific side-effects were identified and/or quantified in this study
Additional remarks	