Methods for quantifying the environmental and health impacts of food consumption patterns

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Methods for quantifying the environmental and health impacts of food consumption patterns

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Contents

Executive summary

Our diets, or food consumption patterns, have a significant impact on the environment as well as on our health. To reduce this impact, it is important first to gain a clear understanding of the methods available to quantify these impacts and of the degree of harmonization between the methods. The aim of this study was to review these methods and the data used to assess the environmental and health aspects of food consumption patterns.

This report presents the results of a literature review of about fifty publications on the environmental and/or health impacts of food consumption patterns. We concentrated on studies carried out within Europe (more than 80% of the studies analysed). We analysed the methods and tools used to quantify environmental effects, the way health aspects of diets are described and quantified, how present food consumption patterns are defined and the types of data used. The review method and draft findings were discussed with experts during two web conferences.

The main findings of the literature review are as follows:
- The relation between greenhouse gas emissions and (healthy) food consumption patterns is the most frequently studied topic. Other commonly used environmental impact categories were land use (land occupation) and the use of fossil fuels. Life cycle assessment was the most frequently used method to quantify environmental impact.
- In most studies the health aspects of food consumption were restricted to the nutritional value of food. Several attempts have been made to derive an overall indicator to quantify or qualify the nutrient value of diets (food consumption patterns), but these were not successful. This means that just a few basic indicators were used; only a few studies used a broader range of indicators of nutritional value.
- Present consumption patterns and diets were defined and quantified in different ways, depending on the data available and the scale of the analysis (global, national, regional or plate level).
- Most studies compared present food consumption patterns to alternative and healthy diets. These studies were mainly 'What If' or scenario studies. We found only one study that developed an optimized diet based on health (nutrient value) and environmental targets.

The study of the health and environmental aspects of food consumption patterns is a relatively new discipline. Further development of this discipline will require environmental and nutritional researchers to learn each other's 'language'. In this regard, we make the following recommendations:
- To further our understanding of the environmental impact of food consumption and the interrelation between different environmental issues we need to incorporate multiple environmental issues into the assessments of healthy and environmental friendly diets. However, it will be more feasible to set priorities and start with global impacts: biodiversity loss due to land occupation, greenhouse gas (GHG) impacts and fossil energy use. At a later stage the scope of the impacts included in assessments can be extended to water and the disruption of environmental mineral flows.
- Large quantities of data are needed to analyse the health and environmental impacts of food consumption. We recommend developing a database containing environmental and nutritional data on food that are derived using the same methodology (consistency) and that can easily be updated.
- The development of food-based dietary guidelines (FBDG) should include both health and environmental aspects. To this end a tool needs to be developed to help nutritionists include environmental aspects when developing FBDG.
- We recommend the development of a harmonized European database of national and regional food consumption patterns and other surveys (e.g. food wastage) for use by researchers and policy makers.

Samenvatting

Ons dieet heeft een aanzienlijke impact op het milieu en op onze gezondheid. Ter vermindering van deze impact is het belangrijk een inzicht te krijgen in de beschikbare methoden om deze effecten te kwantificeren en de mate van overeenstemming over de gebruikte methoden. Het doel van deze studie was om een overzicht te geven van de beschikbare methoden voor de kwantificering van milieu en gezondheidseffecten van voedingspatronen.

Dit rapport presenteert de resultaten van een literatuurstudie van ongeveer vijftig publicaties die de milieu- en gezondheidseffecten van voedselconsumptie kwantificeren. We concentreerden ons op studies die binnen Europa zijn uitgevoerd (> 80% van de geanalyseerde studies). Wij analyseerden de methoden om de milieueffecten te kwantificeren, de wijze waarop gezondheidseffecten zijn beschreven, hoe de huidige voedselconsumptie is gedefinieerd en welke gegevens daarvoor worden gebruikt. De opzet van de literatuurstudie en de resultaten werden met experts besproken tijdens twee webconferenties.

De belangrijkste bevindingen van de literatuurstudie zijn;
- De relatie tussen broeikasgasemissie en voedingpatronen is de meest bestudeerde relatie binnen onze literatuurstudie. Andere vaak bestudeerde milieueffecten zijn landgebruik en het gebruik van fossiele energie. Levenscyclusanalyse is de meest gebruikte methode om de milieu-impact te kwantificeren.
- In de meeste studies worden de gezondheideffecten gekwalificeerd door de voedingswaarde van het geconsumeerde voedsel weer te geven (meestal met één of enkele indicatoren). Slechts in een paar studies wordt gebruik gemaakt van een breder scala van indicatoren. Er bestaat geen allesomvattende indicator die de voedingswaarde van diëten weergeeft.
- Het huidige voedingspatroon wordt op verschillende manieren gekwantificeerd, afhankelijk van de beschikbare gegevens en de omvang van de analyse (mondiaal, nationaal, regionaal of bord- niveau).
- In de meeste studies wordt een huidig voedingspatroon vergeleken met een alternatief en/of gezond dieet. Dit zijn vooral scenariostudies. We vonden slechts één studie, die vanuit de milieudoelstellingen en voedingskundige randvoorwaarden een optimaal menu ontwikkelt.

Het onderzoek naar een gezond en duurzame voedingspatroon is een relatief nieuwe discipline. Verdere ontwikkeling van deze discipline vereist dat milieu en voedingsonderzoekers elkaars 'taal' gaan leren. Voor de verdere ontwikkeling doen wij de volgende aanbevelingen:
- Om een goed begrip te krijgen van de milieu-impact van ons voedingspatroon moeten we meerdere milieuaspecten analyseren. We stellen daarbij voor om te beginnen met de mondiale milieuproblemen verlies van biodiversiteit als gevolg van landgebruik, uitstoot van broeikasgassen en het gebruik van fossiele energie. In een volgende fase kunnen de aspecten watergebruik en verstoring van het nutriëntenkringloop bestudeerd worden. Deze volgorde heeft zowel te maken met relatief belang en de complexiteit om milieuproblemen te operationaliseren.
- In dit onderzoek zijn grote hoeveelheden gegevens nodig. We raden om een database te ontwikkelen met gegevens van milieu- en voedingswaarde per product, afgeleid met behulp van dezelfde methodiek. Daarnaast moet de database flexibel zijn, d.w.z. dat deze eenvoudig kan worden aangepast als er nieuwe (methodologische) inzichten zijn.
- Betrek bij de ontwikkeling van richtlijnen gezonde voeding ook milieuaspecten. Daartoe raden wij aan een instrument te ontwikkelen dat voedingsdeskundigen helpt bij het ontwikkelen van gezonde én milieuverantwoorde richtlijnen.
- Wij adviseren een verdere harmonisatie van nationale en regionale voedselconsumptie en andere relevante gegevens (bv. voedsel verspilling) in Europa zodat gegevens vergelijkbaar zijn voor onderzoekers en beleidsmakers.

1 Introduction

Our diets (food consumption patterns) have a significant impact on the environment. The total production cycle from soil to plate requires a large amount of fossil energy and contributes to climate change, eutrophication and depletion of natural resources. Food consumption accounts for a major component of the environmental impacts of individual consumption. Within the EU-25, approximately one third of the total environmental impact of household activities is related to food and drink consumption (EEA 2005). To reduce this impact it is important first to gain a clear understanding of the methods available to quantify the impacts of food production, distribution and consumption. We then need to establish the overall size of these impacts and assess the effects on the impact of changes in consumption patterns.

Besides environmental impact, diets have an impact on our health. Good health depends on the consumption of sufficient nutrients and energy. Malnutrition can be divided into undernutrition and overnutrition, both of which cause health problems. Undernutrition results in deficiency disorders, such as physical stunting and mental retardation. Overnutrition results in medical problems, such as obesity, heart diseases and diabetes. Dietary habits can therefore support or prevent diseases such as obesity, diabetes, cardiovascular diseases, osteoporosis, cancer and dental diseases (WHO Europe 2004). For the developed world in particular, an unhealthy diet is high in salt, fats and free sugars, and low in fruit, vegetables and complex carbohydrates.

There is growing interest in quantifying the environmental impact of diets (food consumption patterns) and the number of organizations studying the environmental and health impacts of diets is increasing. For example, the Seventh International Conference on Life Cycle Assessment in the Agri-Food Sector, held in Bari in September 2010, devoted a session to this subject ('sustainable diets').[1] More recently, the Health Council of the Netherlands (2011) analysed whether a healthy diet is also a sustainable one from an ecological point of view, using different methods to analyse and quantify the environmental and health impacts of diets.

Different networks of organizations work on food consumption patterns and environmental assessments. These networks focus either on environmental assessment (e.g. LCA in the Agrifood Sector) or on the health impacts of food consumption patterns (e.g. The European Food Information Council). There is as yet no research network for the exchange of knowledge and methods for assessing the environmental and health effects of different consumption patterns.

The Dutch Ministry of Economic Affairs, Agriculture and Innovation (EL&I) is interested in methods and instruments (tools) that the hospitality, catering, food and beverage industries and the retail sector can use to inform consumers about a healthy and sustainable diet. These methods and tools should be based on scientific research and should ideally be applicable in an international context. To this end, the Ministry asked Blonk Environmental Consultants to make an inventory of European organizations working in this

[1] Two papers presented at the conference were by Saxe H. et al., 'Relative GHG footprint of two healthy Nordic diets' and by Saarinen M. et al., 'A lunch plate model as a functional unit of food LCA and a basis for environmental communication'. Both papers were published in: Notarnicola B. et al. (editors), 2010. LCAFOOD 2010. VII International Conference on Life Cycle Assessment in the Agri-Food Sector. Bari, Italy, September 22–24, 2010.

field and the existing tools and methods, and to make recommendations on the development of a harmonized framework for research into healthy and sustainable food patterns.

This study explored the state of the art of research into the environmental and health impacts of diets, based on an analysis of existing publications on this topic. We reviewed the methods used and assessed the current state of knowledge on the subject. From this we draw conclusions about the methods used to assess the environmental and health impacts of food consumption patterns. We also investigated the potential interest in establishing a network of organizations that develop and use tools for quantifying the environmental and health effects of food consumption patterns, for the purpose of exchanging knowledge and experiences in this field.

We set out to answer the following questions:

1. Which organizations are active in quantifying the environmental and health impacts of food consumption patterns?
2. What do they study?
3. Which methods and tools are used or being developed to quantify the environmental and health effects?
4. What general conclusions can be drawn from these studies, focusing on:
    a. the environmental impacts of different diets and dietary guidelines;
    b. the methods used to quantify the environmental and health impacts.
5. Which organizations are interested in exchanging knowledge and experiences in this field? What would be the purpose of a network, and how could it be organized?

In this report we focus on the methodology of quantifying environmental and nutritional impacts of food consumption. We do not give an overview of the results of the studies, for two reasons. First, there is no general framework available for making a proper assessment of combined studies on health and environmental impacts. Second, it is hard to draw general conclusions from studies that use different reporting methods, indicators, aggregation levels and system boundaries, and cover different environmental impact categories.

The methodology and focus of the literature review is set out in Chapter 2. In Chapters 3 to 5 we present the results of the literature review and reflect on these results. Chapter 3 addresses the methods for quantifying environmental impact, Chapter 4 discusses the methods used to analyse the health aspects of food consumption, and Chapter 5 presents the methods used to describe and define diets and food consumption patterns. Annex I gives an overview of the organizations and people involved in this field of research. We end by presenting our conclusions and recommendations (Chapter 6).

2 Methodology of the inventory

This project was carried out in four steps:

1. Inventory of research organizations
2. First consultation with experts on defining the scope of the study and the research questions (webinar held in June 2011)
3. Inventory and review of the literature
4. Second consultation with experts to discuss the draft findings (webinar held in September 2011)

In the first step we made an inventory of organizations and studies on the environmental and health impacts of food consumption patterns. We searched the literature and interviewed experts. In the second step we organized a first webinar with interested researchers to get acquainted with each other, invite comments on the proposed focus and method for the literature review, and to make an inventory of people and organizations working on this topic and collect ideas on establishing a network. We then carried out the literature review (step 3). We asked experts to send us the titles of their own papers and publications and make other suggestions, and used the Wageningen UR Digital Library (primarily life sciences and natural resources publications) to search for other publications. The approach we used for the literature review is described below. In the fourth and last step we organized a second webinar in which the draft results of the literature review were presented and discussed.

For the literature review and discussion with experts we focused on the following subjects:

1. The methods and tools used to quantify the environmental impacts of food consumption and alternative food consumption patterns
2. The methods and tools used to quantify or qualify the health aspects of food consumption and alternative food consumption patterns
3. The description of diets and/or food consumptions patterns, distinguishing between three different approaches:
   - focus on nutrient requirements
   - focus on food-based dietary guidelines
   - formulation of alternative diets: what diets are used and how are they described?
4. Description of current consumption and data used

Figure 1 shows how these topics are related. The starting point is a description and quantification of the food we eat. This can be current food consumption and/or healthy and recommended diets, described as food-based dietary guidelines (FBDG) and/or alternative diets like the 'Mediterranean' diet. Once these diets have been established, their environmental impacts can be quantified.

For the literature review we collected about fifty publications on the environmental and/or health impacts of food consumption patterns. In this review we concentrated on studies carried out in Europe (more than 80% of the studies analysed). Other studies come from the USA and Asia. The scale of analysis in the studies varies from global through European, national and regional to the plate level. The country studies (national, regional and plate level) are from UK, the Netherlands, Sweden, Denmark and Italy. Other countries active in research in this field are Finland, Germany, Norway, Spain and France (see Annex I). A complete overview of the studies we reviewed is presented in Annex II.

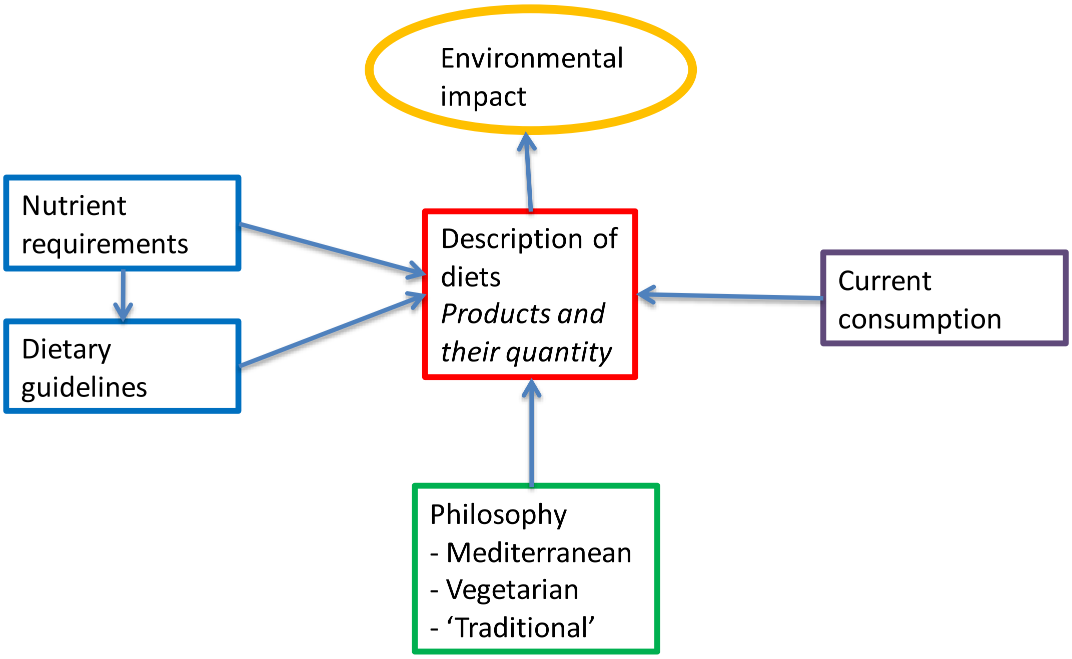

Figure 1 *Topics included in the literature review.*

3 Quantifying the environmental impact of food consumption

3.1 Environmental issues

FINDINGS

The review shows that most studies addressed climate change, followed by land use, fossil energy use and biodiversity, but contained very little coverage of greenhouse gas (GHG) emissions related to land use change. Most of the studies addressed just one or two environmental issues. Besides GHG emissions, some studies also quantified land use and/or the consumption of fossil energy. Figure 2 shows the environmental impact categories covered by the studies.

With a few exceptions, water depletion and soil degradation were not quantified in the studies on food consumption patterns we reviewed. However, more recent publications do pay more attention to the relation between food consumption and water use (see for example, www.waterfootprint.org) and the use and depletion of phosphate. Although there is growing concern about the depletion of phosphate rock (e.g. Cordell et al. 2009), this issue is rarely included in the environmental assessment of food consumption patterns. The experts identified these issues as omissions in the studies, as well as eutrophication and the use of antibiotics in animal husbandry.

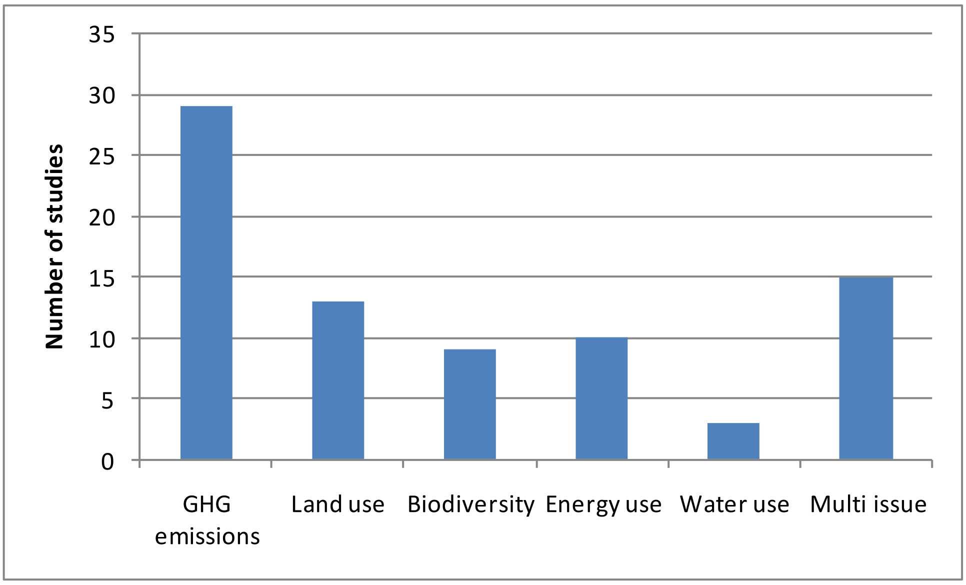

Figure 2 *The numbers of studies reviewed that examined each of the environmental impact categories. Multi-issue indicates that more than 3 impacts categories were assessed. (This figure is based on the information in Annex II.)*

REFLECTION

The primary environmental impact categories related to food consumption and production are GHG emissions, water consumption and pollution, land use, soil degradation, eutrophication and biodiversity loss (Reisch et al. 2010). The Health Council of the Netherlands (2011) concluded that these ecological issues are interrelated and goes on to argue that because of this, the selection of indicators makes little difference to the conclusions at the supranational level. Although we agree that these ecological issues are interrelated, we think that this interrelation is more complex than the Health Council suggests. To fully understand the environmental impact of food consumption and the interrelation between these issues, we need to incorporate multiple environmental issues into the assessments of healthy and environmental friendly diets. We also think that it is useful to make a distinction between global issues and local issues.

As can we see from the results of the literature review, global environmental issues are given the most attention. Apart from the enormous amount of data needed, these impacts are relatively simple to model and calculate. However, food production chains also contribute significantly to local environmental impacts like eutrophication, acidification, air quality and ecotoxicity. The local environmental impacts of food consumption patterns were rarely assessed in the studies we reviewed. One of the reasons for this is that these environmental impacts need to be assessed in combination with local parameters. This information is often not available and is currently not easy to apply in life cycle assessments. When looking at the conclusions of the studies, it is important to be aware of this shortcoming.

For future studies, we recommend starting with the global impacts: biodiversity loss due to land occupation, the impact of GHG emissions and fossil energy use. At a later stage, coverage can be extended to include water and the disruption of environmental mineral flows.

3.2 Methods and indicators

FINDINGS

Most studies used an life cycle assessment (LCA) approach or data from LCA studies to quantify environmental impacts. A few other studies used input-output models or integrated assessment models to quantify environmental impacts. Table 1 presents the methods and indicators used for climate change, land use, fossil energy use, water use, phosphate use and biodiversity in the studies we reviewed. In the third column we give explanatory notes. Annex 4 contains additional information about the methods used to quantify environmental impacts in the studies we reviewed.

Table 1 The main (most common) methods and indicators used to quantify the environmental impact of food consumption in the reviewed studies.

Environmental impact categories	Method / Indicator	Information and comments
Climate change	LCA / kg CO_2 eq Carbon footprint / kg CO_2 eq	GHG emissions from land use and land use change were mostly not included. Methods for carbon footprinting are evolving rapidly and specified for sectors. This specification leads to difficulties when comparing food products because different sector-specific calculation methods are used.
	Global-scale models / CO_2 eq (e.g. IMAGE, Stehfest et al. 2009)	IMAGE simulates changes in energy supply and demand, land use change, changes in vegetation, etc. The difference with the LCA method is that the model represents many feedbacks, such as the impact of climate change on vegetation patterns, crop yields and the carbon cycle.
Land use	LCA inventory / m^2*year	Only a few studies made a distinction between the regions of occupation. This was done in different ways (see Annex 4).
	Integrated assessment model Examples of global-scale models are IMAGE (Stehfest et al. 2009) ALBIO (Agricultural Land use and BIOmass) (Wirsenius et al. 2010)	The IMAGE model simulates land use change as a result of socioeconomic developments. The basic idea of the model is to keep changing gridded land cover within different world regions until the total demands for this region are satisfied. The model output is a (new) land cover map.
Use of natural resources; Fossil energy	LCA inventory / MJ	Energy use can be calculated in different ways. Methods differ with regard to: - the inclusion of the life cycle of the production of the fuel and electricity (delivery energy, conversion and transmission), and - the calculation of the energy content of the fuels.
Use of natural resources; Water use	LCA inventory / m^3 water Water footprint / m^3 water	Inventory means no impact indicators were used. The ISO is working on a standard for water footprinting.
Use of natural resources; Phosphate use	Phosphate rock requirement	Only one study addressed this issue: Reijnders and Soret (2003).
Biodiversity	Ecological footprint / global ha	Mainly used as a communication tool.
	ReCiPe (points) – normalization and weighting method	Weighting methods are not part of international standards.
	Land use / m^2*year	Often used as a proxy for biodiversity.

REFLECTION

Every stage of the production to consumption chain – from growing crops, raising livestock or fisheries to transportation and storage, manufacturing, packaging, distribution, purchasing and consumption, and treating wastes – has environmental impacts (Figure 3). The primary production stage (agricultural production) makes an important contribution to the total environmental impact. The food industry encompasses all stages of the value chain from the farm gate to the point of retail before food purchase and consumption; it therefore covers manufacturers, wholesalers, retailers and food service providers. Energy use and, for some products, packaging materials are important factors in this stage of the production chain. The environmental impacts of food consumption in households and restaurants result mostly from the handling and preparation of food: storage (primarily freezing), cooking and dish washing (Reisch et al. 2010).

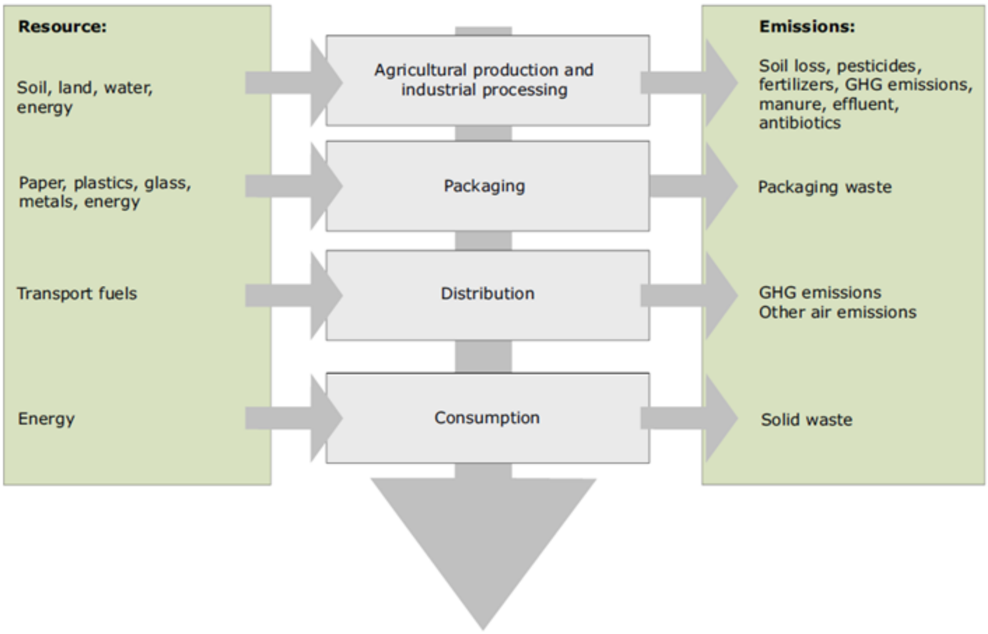

Figure 3 *Environmental impacts of food and drink consumption (source: EEA 2005).*

Life cycle assessment, which considers all the steps in production and consumption processes, is a useful tool for examining the environmental impacts of the entire food production and consumption chain. When using LCA some important assumptions are often made that need to be considered.

- Static approach: The LCA is a static picture of reality. The feedback loops from consumption to production are rarely covered. The only study that made an attempt to do this was by Wolf et al. (2011), who analysed second order effects. By using an economic equilibrium model, they analysed the effect of changes in demand on the levels of production. They concluded that meat production is not reduced to the same extent as the demand. The effects of reduced meat consumptions, including second order effects, is lower than when only first order effects are considered.
- Data quality may differ significantly between studies. Analysing food consumption patterns requires data on different products, but different methodological decisions (system boundaries, allocation, etc) may have been made when calculating these data. This should be borne in mind when interpreting LCA results (see also section 3.3).
- LCA methods do not access some well-recognized environmental impacts of agricultural production. In particular, local biological impacts and the effects of different agricultural practices on landscape are not addressed. Water use is dealt with in a rather simple way.

- Some experts suggested that although LCA is a useful tool for examining the environmental impacts of the entire food production chain, using LCA to analyse food consumption patterns may require too much data to be feasible. This is also discussed in the next section.

3.3 Data

FINDINGS

Considerable amounts of data are needed to analyse the environmental impact of food consumption patterns. In the reviewed studies data were used from many different sources, depending on the country of production and the method used (e.g. system boundaries and allocation method). Several studies explicitly mentioned the issue of significant differences in data quality between studies (e.g. Foster et al. 2006; Sonesson et al. 2010).

Very few studies discussed the uncertainties in their study results. A few authors compared their own calculations with those of other studies (e.g. Garnett 2008) or carried out and discussed an uncertainty study (Audsley et al. 2009 and 2010).

Several studies and databases that provide environmental information on food product groups have recently become available. These databases are very important for conducting assessments on current and alternative diets.

- Agri-footprint.com is an interactive website showing at a glance the environmental impacts of the life cycle of agricultural and food products in terms of GHG emissions, land occupation, energy use and ReCiPe scores. The website explains the calculations and provides a platform for discussing methodological issues in a transparent manner. Furthermore, the database is dynamic, which means that changes in methodology can easily be made for all products in the database.
- LCA food database (www.lcafood.dk) provides LCA data on basic food products produced and consumed in Denmark. It covers processes from primary sectors such as agriculture and fisheries through industrial food processing to retail and cooking:
- Carbonostics (www.carbonostics.com) is an LCA tool designed to pinpoint the hotspots of any food product or menu along three key criteria: cost, carbon and nutrition. The carbon footprint data are from different studies and are therefore not consistent regarding the method of calculation. Moreover, the assumptions and choices made during the calculation of the carbon footprint are not transparent.

REFLECTION

Large amounts of data are required to quantify the environmental impact of food consumption patterns and diets. Because we eat a wide variety of food products in different forms, the environmental profiles of these products and product groups vary considerably. It is therefore important to have environmental information on a sufficient number of products. From our experience, we estimate that approximately 200 products are needed to obtain satisfactory results. It is also important to use region specific data. Public data are not available for all food products. Fairly large quantities of data are available on fresh (agricultural) products, but there is a lack of environmental data on processed food. The quality of the data is often uncertain and varies according to the method used and the methodological decisions made. A single database covering 'all' food products containing data obtained using the same method and assumptions (including decisions on system boundaries, allocation and emission factors) would be a valuable resource for analysing healthy and sustainable diets. Because methods for quantifying environmental impact are evolving, we recommend establishing an integrated, dynamic database in which the calculation method can be updated for all products at the same time. The Agri-footprint.com resource has the potential to become such a database.

The range of uncertainty of the data used should be illustrated and an assessment made of how uncertainties in the data influence conclusions.

4 Quantifying the health aspects of food consumption

4.1 Methods used to qualify and quantify the health impacts of food consumption patterns

FINDINGS

Only one study made use of a diet quality indicator (Figure 4). Ten studies quantified the health impacts of food consumption using a nutrient indicator. The most reported nutrient indicators used were the (dietary) energy content of food and protein content. The most thorough assessment was carried out by Macdiarmid et al. (2011), in which a wide range of nutrient indicators and food recommendation guidelines were analysed and checked while reducing GHG emissions of diets. Table 2 gives an overview of the diet quality indicators used in the studies.

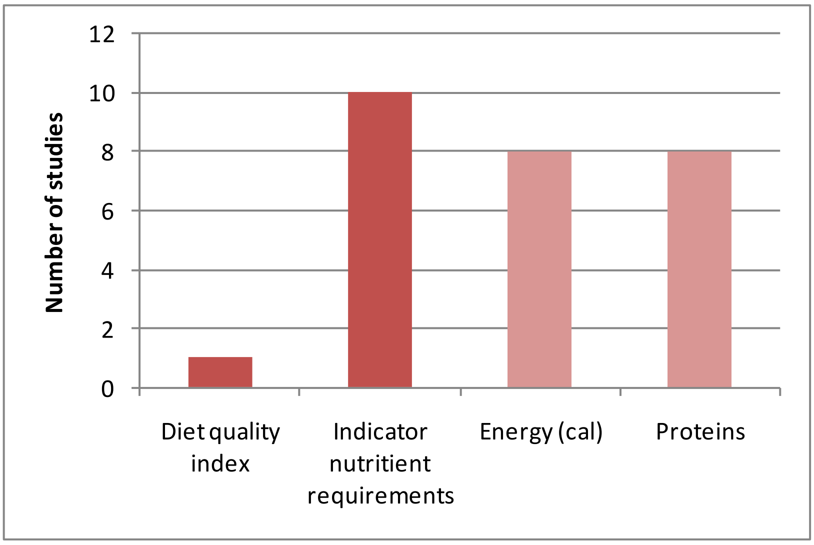

Figure 4 *Number of reviewed studies describing the health impacts of food consumption (total number = 47). (This figure is based on information contained in Annex II.)*

A larger number of studies took a qualitative approach to assessing the health impacts of food consumption, using national or other dietary recommendations, such as food pyramids, the 'Wheel of 5' or the 'Eatwell plate'. Some authors mentioned that a nutritionist checked the nutrient value of the alternative diet and its consistency with the dietary guidelines.

Smedman et al. (2010) made a first attempt to analyse the relation between GHG emissions and nutritional quality by developing the nutrient density indicator. The nutrient density is a percentage of the Nordic Nutrition Recommendations (NNR) for 21 essential nutrients and is related to GHG emissions from the production of a product from a life cycle perspective. This results in a Nutrient Density to Climate Impact (NDCI) index. The NDCI index was calculated for different beverages and not for food consumption patterns. During the web conference all the experts agreed that this is just a simple index that does not encompass the full nutritional spectrum and does not include aspects of bioavailability. Furthermore, it focuses on just one environmental issue. Including other nutritional aspects and other environmental issues is needed, but will make the index more complex.

Table 2 Indicators used to qualify nutritional value in the reviewed studies.

Subject	Nutrients/indictors	Literature
Energy content	Calories MJ	e.g. Carlsson-Kanyama and Gonzales (2009), Saxe (2011)
Protein content	grams protein	e.g. Carlsson-Kanyama and Gonzales (2009)
Key nutrients of meat	Zn, Ca, Iodine, Vitamin B12, riboflavin	Millward and Garnett (2010)
Dietary reference values (UK)	Energy, macronutrients (i.e. total fat, saturated fat, total carbohydrate, non-milk extrinsic sugar, protein, fibre (non-starch polysaccharides), micronutrients (i.e. iron, vitamin B12, zinc, calcium, folate) and sodium	Macdiarmid et al. (2011)

REFLECTION

Analysing the health impacts of diets and the methodologies used is a research discipline in itself. Reviewing all the existing methodologies and indicators used to analyse the relation between diets (food consumption patterns) and health is beyond the scope of this study. To start with, it is not easy to find a clear definition of a healthy diet. The WHO (2011) makes specific recommendations for a healthy diet, which include eating more fruit, vegetables, legumes, nuts and grains, cutting down on salt, sugar and fats, choosing unsaturated fats instead of saturated fats, and eliminating trans-fatty acids. A healthy diet also involves consuming appropriate amounts of all essential nutrients and an adequate amount of water. Nutrients can be obtained from many different foods, so there are numerous diets that may be considered healthy. Figure 5 illustrates the relation between health, diet quality and nutritional value in a simplified way.

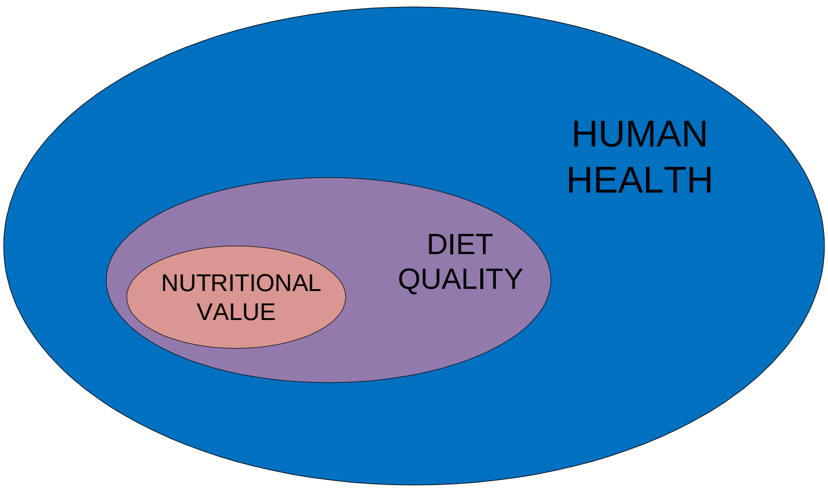

Figure 5 *Simplified relation between health, diet quality and nutritional value.*

During the web conference, experts in the field of human nutrition indicated the difficulty of quantifying diet quality. They recommended starting with two possible approaches to analysing and describing healthy and environmental friendly food patterns: analysing the nutritional value of food, and using food-based dietary guidelines to indicate overall dietary quality, a simpler approach than focusing on nutrition. This second approach is based on the idea that a healthy diet is not determined by individual foods or their constituents, but by an overall dietary pattern. This was also concluded by the Health Council of the Netherlands in its Guidelines for a Healthy Diet (2006). We explain both approaches in more detail below.

4.2 Approaches to defining healthy diets

Nutritional value and diet quality

Food provides nutrients. There are six major classes of nutrients: carbohydrates, fats, minerals, protein, vitamins and water. These nutrient classes can be categorized as either macronutrients (needed in relatively large amounts) or micronutrients (needed in smaller quantities). The macronutrients include carbohydrates (including fibre), fats, protein and water; the micronutrients are minerals and vitamins.

Studying diets and their relation to human health is very complex and involves more than nutrient content alone. The intake of one set of nutrients is often related to others, and for that reason it is often difficult to draw conclusions about the specific effects of nutrients or foods.[2] The use of foods or food groups instead of nutrients may help to capture part of this complexity. Besides, analyses of individual nutrients and foods often ignore the many potential interactions between components of a diet.

Waijers and Feskens (2005) studied existing indices of overall diet quality and tried to select or develop a single overall indicator. They concluded that most of the studied indices of diet quality reflect nutrient adequacy or health outcome to a certain extent, but that these relations are generally weak to moderate and that there are doubts about the validity of the existing indices. They were not able to define a single good overall nutrient quality index. Nevertheless, their publication gives an overview of the attributes of diet quality that should be included in assessments or indices of diet quality (see Table 3).

An indicator used to assess healthy and cheap food is the Nutrient Rich Food (NRF) Index, a scoring system that ranks foods according to nutrient content. It was developed and used in conjunction with a food prices database to identify foods that are both nutritious and affordable. NFR is calculated by adding up the percentage of the daily values of 9 'positive' nutrients (protein, fibre, vitamin A, vitamin C, vitamin E, calcium, iron, magnesium and potassium) and subtracting percentages of the maximum recommended values for 3 nutrients whose intake should be limited (saturated fat, added sugar and sodium). This could be a useful index for use in assessing healthy and environmental friendly diets.

[2] For example, diets high in fibre tend to be high in vitamin C, folate and various carotenoids. When an association is detected between fibre and disease risk, is it certain that the relationship is not a consequence of folate or carotenoid intake (Waijers and Feskens 2005)?

Table 3 The main attributes included in theoretically defined indices of diet quality (source: Waijers and Feskens 2005).

Nutrients - fat-related variables: total fat, saturated fat, cholesterol, MUFA/SFA - carbohydrates: (complex) carbohydrates, mono- and disaccharides, sucrose - dietary fibre - protein - micronutrients: sodium, calcium, iron, vitamin C - alcohol
Foods or food groups - vegetables and fruit: vegetables, vegetables and fruit, fruit, fruit and nuts, legumes - legumes and nuts, etc. - meat and meat products - cereals or grain - milk and dairy products - others: fish, olive oil, cheese
Dietary diversity or dietary variety: Dietary variety is generally made operational as the quantity of different foods or food groups consumed in a given period of time.
Dietary moderation: An indication that we should not eat too much and not consume too much of certain nutrients (e.g. alcohol and saturated fat).

From the above, we may conclude that:
- when analysing the nutritional value of food, we need to include both macro- and micronutrients;
- nutrients are just one part of diet quality, and dietary diversity and dietary moderation are important aspects to consider when assessing the health impacts of food;
- there is no 'single overall indicator' to quantify diet quality.

Food-based dietary guidelines

Guidelines for a healthy diet are principally concerned with the intake of nutrients and contain only a few recommendations on actual foods. Turning the guidelines for a healthy diet into food guidelines therefore involves their translation into food-based dietary guidelines (FBDG) for public information purposes. Examples are the food pyramid used in Italy, the 'Wheel of 5' used in the Netherlands and the 'Eatwell plate' used in the UK.

FBDG are simple messages on healthy eating aimed at the general public. They give an indication of what a person should eat in terms of foods rather than nutrients, and provide a basic framework for planning meals or daily menus. The characteristics of FBDG as described by the World Health Organization (WHO 2003) are that they:
- express the principles of nutrition education mostly as foods,
- are intended for use by individual members of the general public, and,
- if not expressed entirely as foods, are written in language that avoids, as far as possible, the technical terms of nutritional science.

Annex V describes how national FBDG are developed.

5 Description of diets and food consumption patterns

5.1 Description of current food consumption patterns

FINDINGS

Different datasets are needed to assess the environmental and health impacts of current food consumption patterns. For health impacts it is important to know the types and amounts of foods that are consumed. For the nutritional value of food, it is also important to know how it is prepared (e.g. fresh, boiled or fried) because the nutritional value changes depending on the way it is processed, cooked and stored. For an assessment of environmental impacts it is important to know how much food is produced and where, as well as information on storage, preparation and wastage. Figure 6 illustrates the information about current food consumption that is needed to quantify its environmental and health impacts.

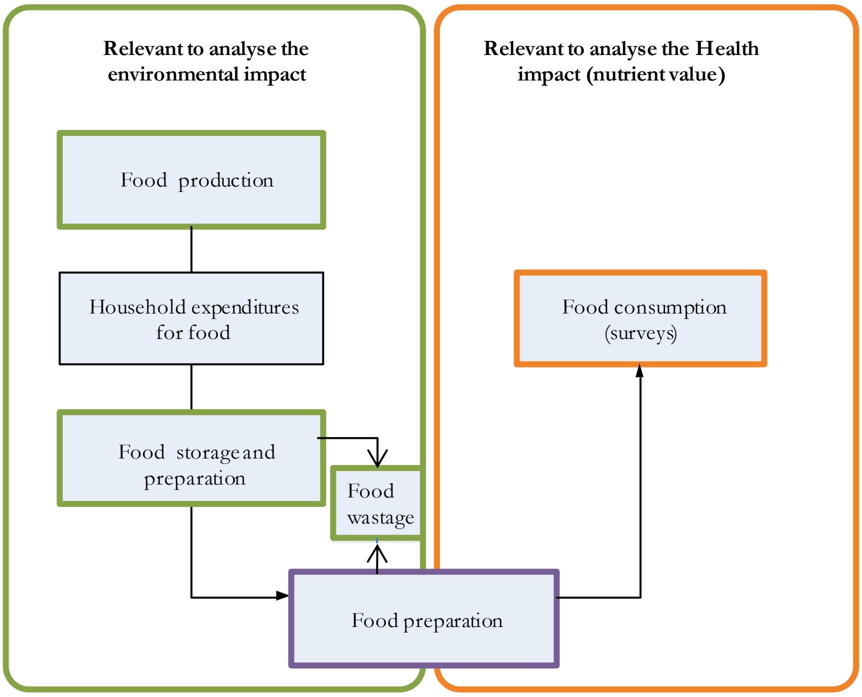

Figure 6 *Information needed to quantify the environmental and health impacts of present food consumption.*

Almost half the studies we reviewed described and quantified current food consumption patterns (see also Figure 7 in section 5.2), but in different ways. The scale and scope of the studies varied from global to national and subnational or regional to plate level. This influences the way food consumption is defined and the way data are collected. Most studies focused on the national level, either by using national food consumption surveys, FAO food balance sheets or household expenditures. Table 4 gives an overview of the approaches and data used to describe present food consumption patterns in the reviewed studies, broken down by scope. The data and methods used varied considerably from study to study.

Table 4 Selection of representative methods used to describe and quantify present food consumption patterns in the reviewed studies. The methods are grouped according to the scope of the studies: global scale, European scale, national scale, regional scale and plate level.

Scope / aggregation level *and issues included*	Approach	Literature example
Global scale		
Food consumption based	The model calculates the consumption of and trade in agricultural products by taking regional and world market prices into account (based on capital, labour and land prices).	Stehfest et al. (2009)
Food production based	Projections of global food agriculture for 2030 (from FAO).	Wiersenius et al. (2010)
European scale		
Food expenditure based, derived from production, import and export statistics	FAO food balance sheets provide data across the EU 27. These sheets include data on production, trade, feed and seed, waste and consumption. Elements covered are quantities, calories, proteins and fats.	Tukker et al. (2009)
National scale		
Food expenditure based, derived from statistics on expenditures	The assessment of household consumption is based on household expenditure and prices of consumption items in the Netherlands.	Gerbens-Leenes et al. (2002)
Food intake based, compiled from a food consumption survey and production chain data derived from statistics on wastage and national production and trade, combined with LCA information on production and preparation	FAO food balance sheets are used to quantify net UK imports, production and consumption of food commodities. Defra's Family Food datasets (UK) were used to quantify consumption. These datasets contain values for home and eating out consumption. Wastage rates were taken from the Family Food Survey, together with the original source in WRAP's food waste study (WRAP 2008).	Audsley et al. (2009)
Food intake based, compiled from a food consumption survey and production chain data derived from statistics on wastage and national production and trade, combined with LCA information on production and preparation	Current food consumption was based on the Dutch National Food Consumption Survey.	Marinussen et al. (2010)

Table 4 (continued) Selection of representative methods used to describe and quantify present food consumption patterns in the reviewed studies. The methods are grouped according to the scope of the studies: global scale, European scale, national scale, regional scale and plate level.

Scope/ aggregation level *and issues included*	Approach	Literature example
National scale (continued)		
Food intake based, compiled from a food consumption survey and production chain data derived from statistics on wastage and national production and trade, combined with LCA information on production *Food preparation was not included*	Current food consumption was compiled from the 1998 results of the Dutch food consumption survey (VCP). The consumption levels of products based on the 1998 figures were compared with data from other sources on Dutch consumption (Statistics Netherlands, and production and apparent consumption statistics from trade associations).	Blonk et al. (2008)
Regional scale		
Food expenditure of different social groups	Cardiff's food consumption was based on household expenditure on food and drink using the classification of individual consumption and different neighbourhood classifications for Cardiff.	Collins and Fairchilds (2007)
Plate level		
Food consumption based	Actual Italian diet, equivalent to the average Italian weekly diet, with food from conventional farming (data from Eurostat, Euromeat and FAO).	Baroni et al. (2007)

REFLECTION

Data on food production, food expenditures, food wastage and food consumption surveys differ per country. Work is already progressing at the European level on harmonizing methods for food consumption surveys. The findings of the EFCOSUM project (European Food Consumption Survey Method) emphasize the need to coordinate nutritional surveillance activities across the European Union. The project revealed that the diversity of approaches to assessing dietary intake at the individual level is huge. As a consequence, available datasets on dietary intake at the country level are not directly comparable. The EPIC-SOFT program, developed by the International Agency for Research on Cancer, was recommended by EFCOSUM as the first choice tool for collecting food consumption data in future pan-European monitoring surveys.

5.2 Description of alternative diets

FINDINGS

In many of the studies we reviewed, current food consumption patterns were compared with alternative and healthy diets. These studies are mainly 'What If' studies (scenarios). One study developed an optimized diet based on environmental and health (nutritional value) targets using a linear programming model (Macdiarmid et al. 2011).

In more than 50% of the studies, alternative diets were formulated to assess the environmental impacts. We identified two main groups of formulated diets. The first group consists of healthy diets. The second group consists of diets based on a various philosophies: the reduction of red meat, vegetarian and vegan diets, as well as diets formulated to reflect particular consumption attitudes to illustrate the difference between organic and conventional products, local and global sourcing of products, and fresh and processed food. Figure 7 shows the number of studies using alternative diets. Table 5 describes the alternative diets assessed in the reviewed studies.

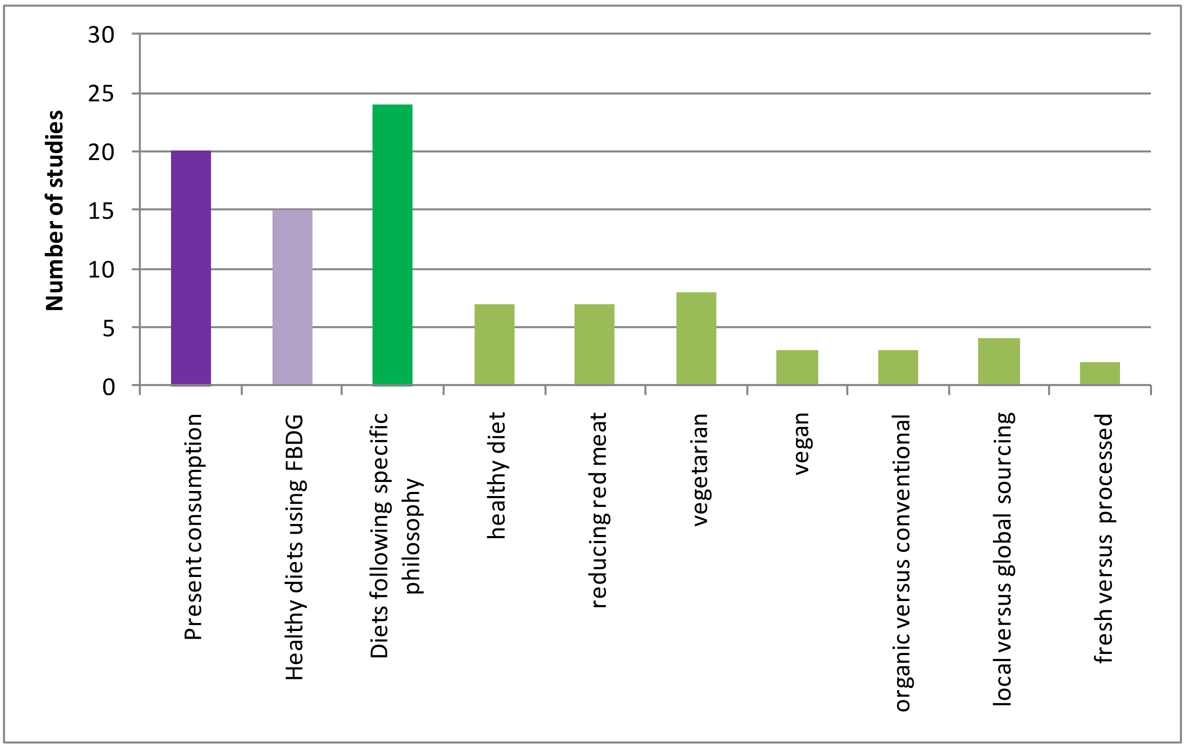

Figure 7 *The number of studies (total = 47) that assessed current food consumption patterns, diets based on FBDG and diets following a specific philosophy. The light green bars are a breakdown of the diets represented by the dark green bar. (The figure is based information described in Annex II.)*

Table 5 The alternative diets found in the literature review.

Main issue	Diets/guidelines	Comment/reference
HEALTHY DIETS		
	Based on national FBDG	
	Based on WHO dietary guidelines	
	Based on World Cancer Research Fund	Diet with a strong reduction of red meat intake.
	Willet diet	Willet (2001)[3]
	Mediterranean diet	
DIETS following a certain PHILOSOPHY		
Animal protein	Reducing (red) meat	A shift from red meat (beef and lamb) to white meat (pork and poultry), or a complete substitution of meat from ruminants.
	Vegetarian	Complete substitution of fresh and processed meat.
	Vegan	Complete substitution of all animal proteins.
Organic versus conventional production	Diets based on organic products versus diets based on conventional products	Some people also claim health impacts in relation to better organic food quality.
Local versus global sourcing	Diets based on local products versus diets based on products that are globally sourced	(no health impact)
Fresh versus processed food	Diets based on fresh products versus diets based on processed food	(health impacts are not analysed)

REFLECTION

Most studies apply a 'What If' (scenarios) approach. These studies give insights into which diets (food consumption patterns) would improve health and/or environmental impacts. An optimization study could answer the question of what an optimal diet would look like. Macdiarmid et al. (2011) developed an optimized diet using a linear programming model. The model optimized the diet by selecting quantities of food from a list of food groups that meet a set of dietary requirements and then minimizing the GHG emissions. It is a useful method for generating different types of diets, while applying constraints that must be met, such as nutrient recommendations and a minimization of environmental impact (in this case GHG emissions).

[3] Willett W.C. (2001) *Eat, Drink, and Be Healthy: The Harvard Medical School guide to healthy eating*. New York: Simon & Schuster.

6 Conclusions and recommendations

6.1 Conclusions

There is growing interest in quantifying the environmental impact of diets (food consumption patterns) and the number of organizations studying the environmental and health impacts of diets is increasing. In this study we analysed the state-of–the-art research on the environmental and health impacts of diets, focusing on the methods used to quantify the environmental and health impacts of food consumption patterns. We carried out a literature study to review the following subjects:

1. The methods and tools used to quantify the environmental impact
2. The methods and tools used to quantify or qualify the health impacts of food consumption
3. Descriptions of current consumption patterns and the data used
4. The description of alternative healthy and environmental friendly diets and/or food consumptions patterns

The results of the literature review were presented and discussed with an international group of experts (see Annex 1). From the review and discussions we draw the following conclusions.

<u>**Quantification of the environmental impact**</u>

Environmental issues

- The environmental impact categories most frequently addressed in the analysis of healthy and environmental friendly food consumption patterns are climate change, land use, biodiversity and energy use, which are the global environmental issues. These impacts are relatively easy to quantify, at least much more easily than local environmental impacts like eutrophication, acidification, air quality and ecotoxicity. Due to the complexity of quantifying environmental impacts at the local level, they are rarely addressed in studies of the environmental impact of food consumption patterns.
- Most studies examined one or two environmental issues. A few studies included a wide range of environmental issues.
- Environmental issues are strongly interrelated. In view of the complexity it is sensible to restrict assessments to a limited set of impact categories, such as GHG emissions, fossil energy use and land use related biodiversity loss. However, it should also be borne in mind that the results for global environmental issues do not necessarily give a sound indication of the local impacts.

Methods

- LCA is the most widely used method for quantifying environmental impacts, followed by input-output analysis and integrated assessment models. Input-output analysis and integrated assessment models are mainly used for studies at the global and national levels.
- LCA is the best available tool for analysing the environmental impact of food consumption. There are, however, some shortcomings and complexities. The need for large quantities of data in particular have limited the output of LCA results on food products. Moreover, the details of the LCA methods used often vary from study to study, which can affect the results significantly and make it difficult to compare studies. Most studies made use of LCA results from different sources and only rarely was all the LCA information calculated consistently. Although this is a time-consuming task, it is nevertheless essential for appropriate dietary environmental impact assessments.
- Carbon footprinting and water footprinting methods as well as methods for analysing biodiversity impacts are developing rapidly. It is important to keep pace with these developments and align

assessments accordingly, but unfortunately various food sectors are developing their own specific methods, which does not help to make results comparable.
- Most studies did not include an uncertainty analysis. It is important to look more closely at how uncertainties influence conclusions on the environmental impact of food consumption patterns.

Data
- Large volumes of data are needed to quantify the environmental impact of food consumption patterns and diets. First, we eat a wide variety of food products and so data are needed on all these food products. It is also important to use region-specific data. For some food products there are no data available. Fairly large volumes of data are available for fresh (agricultural) products, but few environmental data are available for processed food.
- The accuracy of data is often uncertain and varies according to the method used and the methodological decisions made. A single database covering 'all' food products and containing data derived using the same method and assumptions (such as system boundaries, allocation and emission factors) would be a very useful resource for the analysis of healthy and sustainable diets. Such a database should contain information on the uncertainty range of the data.

Quantification and qualification of health impact

Definition of a healthy diet
- Analysis of the health impacts of diets and the methodologies used is a research discipline in itself. Reviewing all the existing methodologies and indicators used to analyse the relation between diets (food consumption patterns) and health was beyond the scope of this study.
- There is no single clear definition of healthy diets. The health impacts of food consumption can be expressed using one or more indicators of diet quality. One aspect of diet quality is the nutrient content of the diet.

Methods for quantifying/qualifying the health aspects of food consumption patterns
- We found two approaches to quantifying and qualifying the health aspects of food consumption (patterns) in the studies we reviewed:
  1. Dietary quality and nutritional value
  2. Food-based dietary guidelines
- In most studies we reviewed, the nutritional value of food was qualified using a few basic indicators like dietary energy and protein content. Only a few studies used a broader range of macro- and micronutrients. There are many ways to quantify the nutrient quality of food consumption, but a single good overall indicator for nutrient quality does not exist.
- The formulation of healthy diets is complex and involves more than just nutritional value. However, at this stage in the development of this young research field it is advisable to focus on the nutritional value of food and food-based dietary guidelines.

Formulation of current food consumption patterns
- The scale and scope of the reviewed studies vary considerably, from global, national and subnational or regional to plate level. This also influences the way food consumption is defined and the way data are collected.
- We found different ways in which current food consumption patterns or diets are described and quantified. The studies focused either on consumption data or production data. Only a few studies calculated both production and consumption data.

- To quantify the environmental and health impacts of diets or food consumption patterns, information is needed on food production, food purchase (household expenditure), food storage and processing, food preparation, food wastage and food consumption (see Figure 6).

Alternative diets

- In many of the studies we reviewed, current food consumption patterns were compared with alternative and healthy diets. These alternative diets are described as healthy diets (e.g. Mediterranean diet) or diets following a certain philosophy (e.g. less red meat, vegetarian and vegan diets, local versus global sourcing, and organic versus conventional products).
- The studies are mainly 'What If' studies (scenarios), which give an insight into which diets (food consumption patterns) would improve health and/or environmental aspects. An optimization study could answer the question of what an optimal diet would look like.

Eating is not just a case if ingesting the right nutrients; it also has a social function and is culturally determined. The analysis in our study addresses only the health and environmental impacts of diets. When translating the results of health/environmental diet studies into recommendations it is important to consider general dietary habits and social and cultural aspects as well.

6.2 Recommendations

More environmental issues

To obtain a better understanding of the environmental impact of food consumption and the interrelation between different environmental issues, we need to incorporate multiple environmental issues into assessments of healthy and environmental friendly diets. We also think it would be useful to make a distinction between global issues and local issues. We recommend starting with the global impacts: biodiversity loss due to land occupation, GHG emissions and fossil energy use. At a later stage coverage can be extended to include water and the disruption of environmental mineral flows.

Develop a database in which environmental and nutritional data on food are presented (and kept up to date)

It is necessary to develop a database covering 'all' food products containing data obtained using the same method and assumptions (such as system boundaries, allocation and emission factors). The database should be dynamic so that the most up-to-date method can be used, and it should also contain information on the uncertainty range of the data. The Agri-footprint.com database could be used for this purpose. Such a database should also make use of existing nomenclature of food products.

Develop FBDG from both the health and environmental viewpoints

The development of FBDG should include both health and environmental aspects. To this end a tool needs to be developed that can help nutritionists to take account of environmental aspects in FBDG. The first step is to work with stakeholders to identify the criteria to be met by this tool.

Consistency in food consumption and other surveys

Develop a European database of harmonized national, and possibly also regional, food consumption and other surveys (e.g. on food wastage) for researchers and policy makers.

Studying the health and environmental impacts of food consumption patterns is a relatively new research discipline. Environmental and nutritional researchers need to learn each other's 'language' to further develop this discipline.

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Annex I Overview of organizations and experts

Organization	Expert	Joined webinar
University of Twente, Faculty of Engineering Technology Civil Engineering. Department of Water Engineering & Management Enschede, Netherlands www.utwente.nl	**Dr. P.W. Gerbens-Leenes** University of Twente Department of Water Engineering & Management P.O. Box 217 7500 AE Enschede The Netherlands Email: p.w.gerbens-leenes@utwente.nl	**27 June, 1 Sept**
University of Groningen, Faculty of Mathematics IVEM Energie en Milieukunde Groningen, Netherlands. www.rug.nl/corporate/ onderzoek/researchinstitutes/ lifesciences/ivem?lang=en	**Dr. Sanderine Nonhebel** IVEM Energie en Milieukunde. Nijenborgh 4 9747 AG Groningen The Netherlands Email: s.nonhebel@rug.nl	**1 Sept**
Swedish Dairy Association Stockholm, Sweden www.svenskmjolk.se/In-English/	**Anna-Karin Modin Edman** Swedish Dairy Association Box 210 101 24 Stockholm Sweden Email: anna-karin.modin.edman@svenskmjolk.se	**27 June**
Cranfield University Cranfield, UK www.agrilca.org www.cranfield.ac.uk	**Dr Adrian Williams** Principal Research Fellow, Natural Resources Management Centre, Building 42A, Cranfield University Cranfield, Bedford, MK43 0AL United Kingdom Email: adrian.williams@cranfield.ac.uk	**27 June,**
MTT Biotechnology and Food Research, Sustainable Bioeconomy Jokioinen, Finland www.mtt.fi	**Merja Saarinen** Research Scientist MTT Biotechnology and Food Research, Sustainable Bioeconomy FI-31600 Jokioinen Finland Email: merja.saarinen@mtt.fi **Juhis (Juha-Matti) Katajajuuri** Email: juha-matti.katajajuuri@mtt.fi	**27 June, 1 Sept**
Martin-Luther-University Institute of Agricultural and Nutritional Sciences Halle-Wittenberg, Germany www.landw.uni-halle.de/	**Toni Meier** Institute of Agricultural and Nutritional Sciences Agronomy and Organic Farming Martin-Luther-University Halle-Wittenberg Betty-Heimann-Straße 5 06120 Halle (Saale) Germany	**27 June, 1 Sept**

	Email:	
National Institute for Public Health and the Environment, Centre for Nutrition and Health Bilthoven, Netherlands www.rivm.nl	**Dr Ir EHM (Liesbeth) Temme** Centre for Nutrition and Health National Institute for Public Health and the Environment RIVM PO Box 1 3720 BA Bilthoven The Netherlands Email: Liesbeth.Temme@rivm.nl **Prof. Dr. Hans Verhagen** Head, Centre for Nutrition and Health National Institute for Public Health and the Environment Email: Hans.Verhagen@rivm.nl	**Both: 27 June, 1 Sept**
FOI Swedish Defence Research Agency Stockholm, Sweden www.foi.se	**Mrs Annika Carlsson-Kanyama,** FOI Swedish Defence Research Agency SE-164 90 Stockholm Sweden Email: carlsson@foi.se	
Corsus – corporate sustainability Hamburg, Germany www.corsus.de	**Dr. Ulrike Eberle** Friedensalle 27a D-22765 Hamburg Germany Email: u.eberle@corsus.de	
TNO Built Environment and Geosciences, Innovation and Environment Delft, Netherlands www.tno.nl	**Dr. Arnold Tukker** TNO Built Environment and Geosciences, Innovation and Environment PO Box 49 2600 JA Delft The Netherlands Email: arnold.tukker@tno.nl **Dr. ir. R.A. (Sandra) Bausch-Goldbohm** Email: sandra.bausch@tno.nl	
Centre for Agriculture and Environment Culemborg, Netherlands www.clm.nl	**Dr Emile Elferink** Centrum voor landbouw en milieu Godfried Bomansstraat 8 4103 WR Culemborg The Netherlands Email: eelferink@clm.nl	**27 June**
Technical University of Denmark Department of Management Engineering Produktionstorvet Kongens Lyngby, Denmark www. man.dtu.dk	**Teunis Dijkman** Teunis Dijkman PhD Student DTU Management Engineering Technical University of Denmark Department of Management Engineering Produktionstorvet	

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European Commission DG Environment Brussels, Belgium www.ec.europa.eu	**Mr Patrice Gruszkowski** European Commission DG Environment Sustainable Production & Consumption B-1049 BRUXELLES Belgium Email: patrice.gruszkowski@ec.europa.eu	
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Mission d'anticipation Recherche/Société & Développement durable, INRA Paris, France	**Barbara Redlingshöfer** MaR/S : Mission d'anticipation Recherche/Société & Développement durable INRA 147 rue de l'Université 75338 Paris Cedex 7 France Email: Barbara.redlingshofer@paris.inra.fr	
Food Climate Research Network UK www.fcrn.org.uk	**Tara Garnett** Food Climate Research Network UK Email: taragarnett@fcrn.org.uk	
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Annex II Literature review

Table II.1 gives a summary of the results of the literature review of about fifty publications focusing on the environmental and health impacts of food consumption patterns. The table shows the environmental issues or impact categories addressed in the studies, the indicators used to analyse nutritional value and the way the diets or food consumption patterns are described. The table is followed by a list of the references and summaries of the publications we reviewed.

Table II.1 Summary of the literature review of studies on environmental and health aspects of diets.

	Environmental impact					**Nutritional value**		**Description of diets**		
Reference number	**GHG emissions**	**Land use**	**Biodiversity**	**Energy use**	**Multi-issue**	**Diet quality index**	**Indictors for nutrient requirements**	**Present consumption**	**Healthy diets using FBDG**	**Diets following a specific philosophy**
(1.1)						x	9 recommended nutrients and 3 discouraged nutrients			
1.2	x	x							x	
(1.3)						x	X			
(1.4)						x				
1.5	x					x				
2.1	x GHG emissions include emissions due to land use change							x	x	x Vegetarian
2.2	x	x								x Reduction in meat Red to white meat Reduction in white meat
2.3	x			x						x
2.4	x			x				x		
2.5	x						x Energy and protein content			x 3 meals with similar nutritional compensation

Table II.1 (continued) Summary of the literature review.

	Environmental impact					Nutritional value		Description of diets		
Reference number	**GHG emissions**	**Land use**	**Biodiversity**	**Energy use**	**Multi-issue**	**Diet quality index**	**Indictors for nutrient requirements**	**Present consumption**	**Healthy diets using FBDG**	**Diets following a specific philosophy**
2.6	x							x	x	
2.7							x Key nutrients of red meat			
2.8	x							x		
2.9	x									
2.10	x	x								x No meat from ruminants Vegetarian Vegan Healthy diet
2.11	x							x		Sustainable diet
2.12	x						X	x	x	70% reduction in GHG emissions
3.1			x							
3.2			x EF*					x		
3.3			x EP					x	x	Vegetarian, Local/not local, Organic/conventional
3.4		x						x		

* EF = Ecological Footprint

Table II.1 (continued) Summary of the literature review.

	Environmental impact					Nutritional value		Description of diets		
Reference number	**GHG emissions**	**Land use**	**Biodiversity**	**Energy use**	**Multi-issue**	**Diet quality index**	**Indictors for nutrient requirements**	**Present consumption**	**Healthy diets using FBDG**	**Diets following a specific philosophy**
3.5		x					Energetic and nutrient content	x		x Basic Subsistence Cultural
3.6		x		x	Water					
3.7		x						x		Ruminant meat substitution Minor vegetarian transition and less food waste
4.1				x			Energy and protein content			
4.2				x						
4.3	x							x		
4.4					x			x		Omnivorous, Vegetarian, vegan Conventional/organic
4.5	x	EP			x Water			x		Mediterranean diet
4.6					x					
4.7	x	x			x			X (USA)		X, Mediterranean diet
4.8	x			x	x					X Organic/conventional Local/not local Fresh/prepared food
4.9	x	x		x				x	x	Vegan Vegetarian Healthy diet Mediterranean
4.10	x		x		x		Energy content (MJ) kg food	x	x	Vegetarian
4.11	x		x		x					2 common meals
4.12	x				x				x	Reduction of meat Healthy diet Mediterranean diet
4.13	x				x				x	Reduction of meat Healthy diet Mediterranean diet

Table II.1 (continued) Summary of literature review.

	Environmental impact					Nutritional value		Description of diets		
Reference number	GHG emissions	Land use	Biodiversity	Energy use	Multi-issue	Diet quality index	Indictors for nutrient requirements	Present consumption	Healthy diets using FBDG	Diets following a specific philosophy
5.1					x					x Local/global food Fresh/processed food
5.2	x		x						x	
5.3	x	x	x	x	X Water		x		x	
6.1	x	x		x			x	x	x	x
6.2	x	x	x		x			x	x	x
6.3	x	x		x	x					x
6.4							x		x	x
(7.1)					x					
7.2	x						x			
7.3	x							x		

The studies between brackets (reference number) are not included in the total number of reviewed studies on the environmental and health impacts of food consumption.

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2. Greenhouse gas emissions of diets (11)

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2.8 Kramer K.J., Moll, H.C., Nonhebel S. and Wilting, H.C., 1999. Greenhouse gas emission related to Dutch food consumption. *Energy Policy* 27: 203–216.

2.9 SIK, 2009. Climate Smart Food. Swedish Institute for Food and Biotechnology, Stockholm.

2.10 Stehfest, E., Bouwman, L., Van Vuuren, D., Den Elzen, M., Eickhout, B. and Kabat, P., 2009. Climate benefits of changing diet. *Climatic Change* 95: 83–102.

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3. Biodiversity – land use – Ecological footprint and diets

3.1 Burlingame, B., Dernini, S., Charrondiere, U.R., Stadlmayr, B., Mondovi, S., Dop, M. and Albert, J., 2010. Biodiversity and Sustainable Diets. International Symposium, Food and Agriculture Organization of the United Nations, Rome, 2010.

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3.2 Collins, A. and Fairchilds, R., 2007. Food Consumption at a sub-national level: An ecological footprint. *Journal of Environmental Policy and Planning* (Special Issue: Sustainable Food Supply Chains) 9(10): 5–30.

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4.1 Carlsson-Kanyama, A., Ekström, M.P. and Shanahan, H., 2003. Food and life cycle energy inputs: Consequences of diet and ways to increase efficiency. *Ecological Economics* 44: 293–307.

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Food Miles (1)

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5.1 Eberle, U., 2010. Review of food LCA results and consumer recommendations on environmentally conscious consumption behavior. Presentation at VII International Conference on Life Cycle Assessment in the Agri-food Sector, Bari, 23 September 2010.

5.2 National Food Administration, 2009. The National Food Administration's environmentally effective food choices. Proposal notified to the EU. Uppsala: The National Food Administration.

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6. Diets: Mediterranean, vegetarian, etc

Focus on (animal)proteins (3)

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Local foods (1)

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7. Tools

7.1 Calculator for the environmental impact of food consumption. Developed by Natural and Social Science Interface, ETH Zurich. Website: www.uns.ethz.ch/

7.2 Carbonostics. Carbonostics is an online application that allows users easy access to a comprehensive carbon emissions database for food ingredients, packaging materials, energy use, and more. Website: www.carbonostics.com/

7.3 Klimaatweegschaal. The 'Climate Scales', developed by the Dutch Food Centre and CLM, is an online tool for informing consumers about the climate impact of their meals and the impacts of their choice of ingredients, cooking and preservation practice. The GHG emissions in the database are expressed as kg CO_2 eq per 100 g of edible product as available in supermarkets. Website: http://www.voedingscentrum.nl/nl/jij-kan-kiezen/klimaatweegschaal-uitgebreid-.aspx

Annex III Tools and database

This annex contains brief descriptions of a number of tools for the calculation of the environmental impact of food consumption.

1. Agri-footprint.com

Blonk Environmental Consultants developed the interactive website Agri-footprint.com to share quantitative information about the sustainability of agricultural and food products. The website is a knowledge base designed for sharing the most recent information and methods for assessing the environmental impacts of products, raw materials and sectors with professional users, such as producers, researchers, industrial and trade associations, policy makers and product innovators. The website also hosts a forum for discussions about methodological issues. Agri-footprint.com contains quantitative results for four environmental impact categories: greenhouse gas emissions, energy use, land occupation and the ReCiPe score. A detailed explanation of the methodology is given in the handbook available on the site.

Agri-footprint.com is a unique medium because it is dynamic, up to date and transparent, and employs the same methodology for the different product categories:

- Agri-footprint.com is dynamic because current knowledge and product results are quickly uploaded.
- Agri-footprint.com is up to date because calculation rules are always based on the most recent methodological standards and because new developments and understanding can be implemented rapidly.
- Agri-footprint.com is transparent because new data and the methodology are publicly available.
- Agri-footprint.com is consistent because the same standards and calculation rules are used for all products and product categories so that they are mutually comparable.

Website: http://www.agri-footprint.com
Methodology: Life Cycle Assessment
Tool sort: Dynamic database

2. Calculator for the environmental impact of food consumption

Umweltfolgen von Lebensmitteleinkäufen
The calculator provides online environmental evaluation of personal consumption habits for vegetables and meat. It includes a comparison with average Swiss consumption for the whole life cycle from production through transport, packaging and preparation to disposal, as well as tips for ecological improvement.
Developed by: Natural and Social Science Interface, ETH Zurich
Website: http://www.ulme.ethz.ch/
Methodology: Life Cycle Assessment
Tool sort: Software

3. Carbonostics

Carbonostics is an online application that allows users easy access to a comprehensive carbon emissions database for food ingredients, packaging materials, energy use and more. It allows a user to create an instant life cycle estimate of any food product or menu.
Website: http://www.carbonostics.com
Methodology: Life Cycle Assessment
Tool sort: Database

4. Simulme: Simulation game to investigate environmental impacts of your consumption pattern

From the website: 'The simulation game SIMULME gives you a feedback concerning the effects of your decisions of food purchasing by presenting economic-ecological scenarios for the development of Switzerland. The effects of the own consumption patterns are demonstrated in an exaggerated, but in the tendency realistic way. Thus this environmental game is an instrument, which emphasizes the ecological and economic effects of own consumption decisions in order to clarify the positive effect of ecologically adapted consumption patterns. Hence, it is not a scientific instrument for the prediction of future ecological-economic developments in Switzerland, but rather an environmental education game.'
Developed by: Natural and Social Science Interface, ETH Zurich
http://www.simulme.ethz.ch/engl/simulme.asp
Tool sort: Simulation game

This game was first used with 215 pupils divided into 12 classes. Six classes were taught the consequences of food consumption using the learning game (experimental condition) and 6 using a standard lecture (control condition). Positive changes in environmental attitudes concerning nutrition behaviour were more marked in the experimental than in the control condition. An additional experiment tested the game's effects on subsequent buying behaviour. After playing the game (experimental) or not (control), participants entered the nutrition section of the online shop of the Swiss retailer Coop with the possibility of winning a purchase worth CHF 40. The consumption pattern of those who played SIMULME was ecologically more positive than that of the control participants (Hansman et al. 2005).

5. Klimaatweegschaal

The 'Climate Scales' online tool, developed by the Dutch Food Centre and CLM, informs consumers about the climate impact of their meals and the impact of their choice of ingredients, cooking and preservation practice. The GHG emissions in the database are expressed as kg CO_2 eq per 100 g of edible product as available in supermarkets.

Methodology: Greenhouse gas emissions in the database are based on life cycle assessments (LCA). Calculations are based on an Energy Analysis Program (EAP) (scientifically validated) and a regional climate model for agriculture, which uses the most recent calculations and data based on the Netherlands National Inventory Report (2008). The calculations and the results of the model are checked by scientists at Wageningen University and Research Centre (WUR) and NL Agency (the Dutch agency for the implementation of government policy for sustainability, innovation and international business and cooperation). A detailed description of the model can be found in a paper by Emiel Elferink (CLM 2008).

6. LCA Food database

This website provides LCA data on a wide range of environmental issues related to basic food products produced and consumed in Denmark. The site covers processes from primary sectors, such as agriculture and fishery, through industrial food processing to retail and cooking. Data are available for the following groups of products: crops and crop-based products, milk and milk-based products, vegetables, meat, fish and packaging.
Website: http://www.LCAfood.dk
Methodology: Life Cycle Assessment
Tool sort: Database

Annex IV Additional information about the methodology for quantifying environmental impact

Climate change
Climate change refers to the significant and lasting change in weather patterns (e.g. temperature) generally thought to be caused by infrared forcing (increased concentration of greenhouse gases in the atmosphere related to human activity). Climate change can have serious direct and indirect endpoint effects on human health and biodiversity.

A method for quantifying the contribution of a food product to climate change is the 'carbon footprint'. It measures the total greenhouse gas (GHG) emissions caused directly and indirectly by a person, organization, event or product. The emissions that occur throughout the life cycle are quantified. The footprint considers all GHGs, the most important for food products being carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).[4]

Greenhouse gas emissions can be expressed as carbon dioxide equivalents. In 1996 and 2007 the IPCC published lists of greenhouse gases and the factors used to convert them into carbon dioxide equivalents, which are called global warming potential (GWP) factors. There are GWP factors for the impact over 20 years and over 100 years. Most international standards, such as ISO14044, ISO14067 and PAS 2050, use the GWP 100 year factors.

There are several protocols for standardizing the calculation method currently available or soon to be published that are in line with the general ISO standards for LCA, for example: PAS 2050 (2008 and 2011[revised edition published 30 Sept]), BP X30-323 (2009 and more recent updates), WRI protocol (draft 2011) and ISO14067 (draft 2011). These methods are not specific for food products, which leaves the user room for interpretation, which in turn can affect the results. However, many initiatives on deriving food sector or product specific specifications are ongoing.

Most of the studies we reviewed use the LCA methodology to quantify the GHG emissions, expressed as kg CO_2 eq. Currently much effort is being put into calculating the carbon footprints of food and beverage products all over the world, which is generating an increasing amount of available data. There is also a high degree of consensus on using the GWP-100 equivalence factors (global warming potential for 100 years) to calculate the impact indicator for climate change. However, there are still several issues related to system boundaries, delayed biogenic carbon emissions and land use change. The following issues were discussed in the literature:

- Most studies do not include land use and land use change. The study by Audsley et al. (2009) is an exception and focuses on GHG emissions from land use, a potentially important parameter for food products. This encompasses more than just deforestation, which is a form of 'land use change', but also the management of soils in general. More research is needed to develop methods for incorporating these issues into LCA and to increase understanding of how carbon flows to and from soils are affected by farm practices.
- The calculation of biogenic GHG emissions (methane and nitrous oxide) is a complex area since these substances are formed in biological systems. Emissions vary depending on variables such as climate and soil type and management.

[4] Refrigerants, which also may be greenhouse gases, mostly have a negligible contribution in food production chains

Land use

Land occupation is the area of rural or urban land that is occupied for a certain period of time and is expressed as total square metres * years. Land occupation may have a considerable impact on ecosystems because natural vegetation and animal life is often strongly affected. This often has negative consequences for biodiversity, not only in the area of land directly affected but also in the surrounding areas. The extent of the impacts depends largely on the type of agricultural activity, such as grassland or arable cropping, and the intensity of the use of inputs (Blonk et al. 2011). Land occupation for agricultural purpose also adds to global warming through the loss of the sink function of the land.

The impact of land use strongly depends on where the land is situated, because background biodiversity and the trends in land use change differ between areas (Blonk et al. 2011). Not all studies on quantifying land use make a distinction between the regions of occupation, and those that do often use different regional categories. A common regional classification is a division into the following three regions:

1.	South America/Southeast Asia	higher risk of biodiversity loss
2.	Europe and North America	lower risk of biodiversity loss
3.	Rest of the world	unknown

At the moment most of the global biodiversity hotspots and much of the area with the greatest rate of land use change (from natural to agricultural or degraded land) are found in South America and Southeast Asia. Land occupation in these regions may have a greater impact on biodiversity loss. Land use (and land cover), biodiversity and ecosystem services are therefore strongly interconnected, although biodiversity is also affected by a wide range of other pressures, such as water scarcity, deposition of toxic and eutrophying substances, invasive species, etc. (Croezen et al. 2011).

Only a few studies consider land occupation without describing the potential impact, such as Gerbens-Leenes et al. (2002) and Gerbens-Leenes and Nonhebel (2005). This method can be considered to be an LCA inventory, which is useful for gaining insight into the use of land, but it does not say anything about the impacts of the land uses, such as biodiversity impacts or emissions of GHG.

More of the reviewed studies considered land occupation and GHG emissions, such as Audsley et al. (2010). In that study the authors analysed the impact on total land use of seven scenarios (changes in food consumption patterns in the UK), distinguishing between land use in the UK and in other countries, and between cropped area and grassland area.

To determine land use for food items, information is needed on yields, imports, food industry recipes and proportions of crops grown in the open air and under glass. For the Netherlands, information on yields is available on different scales (FAO, CBS, IKC-AG). Information on imports is available from Statistics Netherlands (CBS). Uncertainties in land use data arise when more than one crop is grown on a piece of land in a single year, crops are cultivated in a multi-cropping system and when yields strongly fluctuate. When multi-cropping systems are involved, the methodology must include an allocation protocol. The Agri-footprint database described in Annex II presents data on land use (land occupation) for different agricultural and food products.

Biodiversity
The Convention on Biological Diversity (CBD) proposes a set of five indicator categories to represent the state and change in state of biodiversity:

- extent of ecosystems
- abundance and distribution of species
- status of threatened species
- genetic diversity
- coverage of protected areas

There are many methods and indicators for quantifying impacts on biodiversity. In our literature review of studies on the health and environmental impact of food consumption patterns, the most frequently used indicators were land use (discussed above), the ecological footprint and, in one case, terrestrial mean species abundance (MSA). The ReCiPe score was not used in the studies reviewed. However, a recent publication by Croezen et al. (2011) describes the ReCiPe score as a good and valuable indicator for quantifying biodiversity. For this reason we also describe the strength and weaknesses of this indicator in this section, as well as the ecological footprint.

The goal for developing the ReCiPe 2008 life cycle impact assessment method was a harmonized and consistent methodology for as many environmental impacts as possible. In addition to land use and its impact on biodiversity, it includes 17 other environmental issues, both well-known issues such as acidification and climate change and less frequently considered issues such as mineral and fossil fuel consumption. The methodology allows aggregation and weighting of the different impacts into a single environmental damage figure, which is expressed as a points score. The methods include a restoration time for biodiversity. The ReCiPe method is suitable for life cycle material analyses. For more information see Goedkoop et al. 2009.

General criticisms on use of the ReCiPe score to quantify impacts on biodiversity are:

- Differences in landscape design are not included, such as the inclusion of ecological corridors or landscape elements, which are valuable elements for biodiversity.
- The methodology does not consider the uniqueness of a biome in the analysis.

Croezen et al. (2011) looked for an accurate global indicator for biodiversity in material and energy policy. They concluded that better cooperation between LCA scientists (ReCiPe) investigating the environmental aspects of products and biodiversity scenario analysts investigating the biodiversity trends in regions could lead to a biodiversity indicator that is accurate, global, simple and easy to use in LCA studies. Until these mean species abundance[5] and ReCiPe indicators are integrated into a single method, the ReCiPe indicator, with additional data for tropical regions, remains the most suitable indicator for use in life cycle assessments.

Ecological footprint
The ecological footprint (EFP) is an aggregated indicator of the demand on nature and is measured using a standardized area unit termed a 'global hectare' (gha), and is usually expressed on a per capita basis

[5] Terrestrial mean species abundance (MSA) is, in essence, an indicator of the 'naturalness' of ecosystems in the form of a compound result of human-induced pressure factors. It considers the composition of species in numbers and abundance compared with the original state and provides a common framework for assessing the major causes of biodiversity loss (PBL 2010). The MSA and the potential disappeared fraction (PDF) are related: PDF = 1-MSA.

(gha/cap). The EFP estimates the area of land required to support the resource consumption of a defined population, usually for one year. This might be, for example, the demands of that population in terms of their food, travel and energy use. This demand on nature can be compared with the earth's available biocapacity, which translates into an average of 1.8 gha/cap in 2001 (WWF 2006). Collins and Fairchild (2007) used the EFP to measure the environmental impact of food and drink consumption at a subnational level.

Although the EFP is widely used, the concept has faced a number of criticisms. Among the main criticisms are that the footprint does not accurately reflect the impacts of human consumption, it does not correctly allocate responsibilities for impacts, and it does not provide decision makers with a useful tool for policy making as there is limited understanding of how different consumer activities relate to impacts (Collins and Fairchild 2007). An advantage of the EFP is its communicative power; it personalizes sustainability by assessing the impact of consumption from a consumer perspective. The effectiveness of the EFP as a decision support tool has yet to be demonstrated.

Fossil energy use

Fossil energy use refers to the depletion of primary fossil fuels, the main ones being oil, natural gas and coal. The depletion of fossil fuel sources is a major social concern as renewable energy sources cannot be used on a scale that satisfies total energy demand. For food and beverages, energy is mainly used for transport and industry, including the agro-industry.

In many of the studies we reviewed, fossil energy use was quantified in combination with other issues. In a few studies energy use was the only environmental issue analysed (e.g. Carlsson-Kanyama 2003 and 2004; Duthil and Kramer 2000). Carlsson-Kanyama (2004) made an inventory of life cycle energy inputs for 150 food items available in Sweden and discussed how energy efficient meals and diets can be composed. She concluded that energy inputs in food life cycles vary from 2 to 220 MJ per kg due to a multitude of factors related to animal or vegetable origin, degree of processing, choice of processing and preparation technology, and transportation distance.

The most common method for quantifying fossil energy use is to characterize primary fossil energy use during the life cycle and sum the net caloric value of the fuels (lower heating value).

Water use and depletion

Water resource depletion refers to the decreased availability of freshwater in a watershed. This can take place by evaporation or crop evapotranspiration of surface and groundwater and by the transport of water (e.g. incorporated in a product) from one watershed to another.

Freshwater use is an increasingly important environmental topic. For food and beverages, this is very relevant as irrigation for primary production can have a large impact on the environment. Agriculture consumes most water in the world, accounting in some developing countries for up to 90% of water consumption. Changes in diet – in particular the growing consumption of meat – also puts higher pressure on water resources (e.g. Riesch et al. 2010; Liu and Savenije 2008; Hoekstra and Chapagain 2007). However, in the studies we reviewed this environmental topic was seldom analysed.

There is debate on how to calculate the environmental impact of freshwater use. The water footprint method of the Water Footprint Network (WFN) (Hoekstra et al. 2009) calculates water use and water pollution. The water footprint calculates the amount of water used (green and blue water footprint) and polluted (grey water footprint) for a certain product and is expressed as a volume (litres) per unit (kg, litres or units). The WFN method differs from the proposed global ISO standards for life cycle assessment

(ISO14040/44: 2006). The first difference concerns the pollution part (grey) of the water footprint. Better indicators exist to quantify the environmental impact of water pollution in LCA (making a distinction between eutrophication, ecotoxicity, etc.) Second, green and blue water footprints are simply life cycle inventories and do not give provide information about the environmental impact.

The ISO is working on a standard for water footprinting, but it is unknown when it will be published. There are several methods available for calculating an impact indicator for water use, for example:

- Swiss Ecoscarcity (Frischknecht et al. 2008)
- Mila I Canals et al. (2008)
- Ridout and Pfister (2009)

Phosphate depletion

The depletion of mineral resources is an important concern for society, mainly because these resources may eventually become scarce. Increased recovery of resources from recycled products can be a solution for some minerals, but not for all. For food and beverages, the mining of rock phosphates for use as a fertilizer is the most important. Phosphorus is an essential nutrient for growing plants. Humans get the phosphorus they need from food, which in turn comes from the phosphate fertilizers applied to crops. Around 90% of the phosphate rock extracted globally is for food production (the remainder is for industrial applications such as detergents).

Concern about the use and depletion of phosphate and the consequences for food security is increasing. The website of the Global Phosphorus Research Initiative (http://phosphorusfutures.net/peak-phosphorus) shows that a balanced diet results in depletion of around 22.5 kg/yr of phosphate rock (or 3.2 kg/yr P) per person, based on current practice. This is 50 times greater than the recommended daily intake of P of 1.2 g/day/person. In other words, phosphate must be used more efficiently.

The study by Reijnders and Soret (2003) is the only one we found that included phosphate depletion in the assessment of the environmental impact. Reijnders and Soret (2003) calculate phosphate rock requirement for different diets that differ in protein choices.

There are several models available that calculate an impact indicator for mineral resource depletion, including:

- Swiss Ecoscarcity (energy and gravel) (Frischknecht et al. 2008)
- Exergy CEENE (Dewulf et al. 2007)
- CML2002 (Guinée et al. 2002)
- EDIP1997 (Hauschild 2004)

Annex V Development of food-based dietary guidelines

To identify the foods and food groups that should be included in food-based dietary guidelines (FBDG), it is necessary to assess the nutritional status of the target population. An evaluation of the nutritional status of a population is the best way to ensure that FBDG take into account the prevailing nutrient gaps and public health problems of a specific country. In Europe, the main public health problems are diet- and lifestyle-related non-communicable conditions, such as obesity, heart disease, diabetes and cancer. These diseases may partly derive from an excess intake of calorific nutrients and a shortage of certain micronutrients. For these reasons, FBDG need to consider both 'negative' (e.g. 'choose lean cuts of meat' to reduce saturated fat intake) as well as 'positive' messages (e.g., 'X portions of meat, poultry and fish per day' to increase iron intake) (European Food Information Council 2011).

The EFSA Scientific Opinion on establishing Food-Based Dietary Guidelines identifies seven steps for developing FBDG (EFSA, 2010):

1. Identification of diet–health relationships
2. Identification of country specific diet-related problems
3. Identification of nutrients of public health importance
4. Identification of foods relevant for FBDG
5. Identification of food consumption patterns
6. Testing and optimizing FBDG
7. Graphical representation of FBDG

The website of the European Food Information Council gives an overview of the dietary guidelines of most European countries (see: www.efsa.europa.eu/de/colloquiafbdg/publication/colloquiafbdg.pdf).

To develop FBDG that cover both health and environmental aspects, the impact on the environment of food should be included in this process. We recommend developing a tool that can be used for testing and optimizing FBDG for the environmental impacts of food.