TEXTE
86/2016

# Development of tools to prevent food waste

## Short Version of the Final Report

For our Environment

Umwelt Bundesamt

TEXTE 86/2016

Environmental Research of the
Federal Ministry for the
Environment, Nature Conservation,
Building and Nuclear Safety

Project No. (FKZ) 3712 32 311
Report No. (UBA-FB) 002412

# Development of tools to prevent food waste

by

Dirk Jepsen, Dr. Annette Vollmer
Ökopol, Hamburg

Dr. Ulrike Eberle
corsus, Hamburg

Jacob Fels
ZNU, Witten

Prof. Dr. Thomas Schomerus
Leuphana University, Lüneburg

On behalf of the German Federal Environment Agency

# Imprint

**Publisher:**
Umweltbundesamt
Wörlitzer Platz 1
06844 Dessau-Roßlau
Tel: +49 340-2103-0
Fax: +49 340-2103-2285
info@umweltbundesamt.de
Internet: www.umweltbundesamt.de

/umweltbundesamt.de
/umweltbundesamt

**Study performed by:**
Ökopol Institut GmbH
Nernstweg 32-34
22765 Hamburg

**Study completed in:**
December 2014

**Edited by:**
III 1.5 Municipal Waste Management, Hazardous Wastes, Focal Point to the Basel Convention
Barbara Friedrich

**Publication as pdf:**
http://www.umweltbundesamt.de/publikationen

ISSN 1862-4804

Dessau-Roßlau, December 2016

The Project underlying this report was supported with funding from the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear safety under project number FKZ 3712 32 311. The responsibility for the content of this publication lies with the author(s).

## Abstract

In recent years the issue of food waste has received growing attention. In 2011, the Food and Agriculture Organization of the United Nations (FAO) published data about the amount of global food waste which revealed that about 1.3 billion tons per year, or one-third of all food produced globally, is never eaten. At the same time, according to FAO estimates, more than 900 million people suffer chronic hunger. The losses of edible food are a central problem not only for moral and ethical reasons, but also from an environmental perspective. The production and processing of food entail serious environmental impacts which could be reduced significantly by lowering food loss rates.

Against this background, the project is the first to deliver a reliable estimate of the environmental impacts that result from losses during production, distribution, and consumption of food for and by the German population.

Based on an analysis of existing proposals and further possibilities for binding governmental action, specific measures are proposed that are suitable for effectively reducing relevant food waste and that can be realized by the Federal Environment Ministry in the context of the German Waste Prevention Programme.

# Table of contents

# List of figures

# List of tables

# Abbreviations

| | |
|---|---|
| **a** | Year |
| **AbfKoBiV** | Ordinance on Waste Management Concepts and Waste Balance Sheets (*Abfallwirtschaftskonzept- und -bilanzverordnung*) |
| **AFFL** | Working group meat and poultry meat hygiene and specific questions concerning animal-based foods (*Arbeitsgruppe für Fleisch- und Geflügelfleischhygiene und fachspezifische Fragen von Lebensmitteln tierischer Herkunft*) |
| **AG GEE** | Healthy Diet and Nutritional Information Working Group (*Arbeitsgruppe Gesunde Ernährung und Ernährungsinformation*) |
| **ALB** | Working group food, materials and articles, wine, and cosmetics (*Arbeitsgruppe für Lebensmittel, Bedarfsgegenstände, Wein und Kosmetika*) |
| **AR** | Argentina |
| **AT** | Austria |
| **ATV** | Wastewater Technical Association (*Abwassertechnische Vereinigung*, today German Water Association *DWA, Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall*) |
| **AVV LmH** | General Administrative Regulation on the performance of official monitoring of compliance with hygiene rules for foods of animal origin and on the procedure for reviewing guidelines for good procedural practice (*Allgemeine Verfahrensvorschrift Lebensmittelhygiene*) |
| **BAT** | Best available technology |
| **BE** | Belgium |
| **BfR** | Federal Institute for Risk Assessment (*Bundesinstitut für Risikobewertung*) |
| **BGB** | German Civil Code (*Bürgerliches Gesetzbuch*) |
| **BGBl.** | Federal Law Gazette (*Bundesgesetzblatt*) |
| **BioAbfV** | Ordinance on Bio-Wastes (*Bioabfallverordnung*) |
| **BImSchG** | Federal Immission Control Act (*Bundesimmissionsschutzgesetz*) |
| **BLE** | Federal Office for Agriculture and Food (*Bundesanstalt für Landwirtschaft und Ernährung*) |
| **BLL** | German Federation for Food Law and Food Science (*Bund für Lebensmittelrecht und Lebensmittelkunde e.V.*) |
| **BMBF** | Federal Ministry of Education and Research (*Bundesministerium für Bildung und Forschung*) |
| **BMEL/BMELV** | Federal Ministry of Food and Agriculture (and Consumer Protection) (*Bundesministerium für Ernährung und Landwirtschaft (und Verbraucherschutz)*) |

| | |
|---|---|
| **BMUB** | Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (*Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit*) |
| **BR** | Brazil |
| **BVL** | Federal Office of Consumer Protection and Food Safety (*Bundesamt für Verbraucherschutz und Lebensmittelsicherheit*) |
| **cf.** | See |
| **Ch.** | Chapter |
| **CO** | Colombia |
| **CR** | Costa Rica |
| **CZ** | Czech Republic |
| **DE** | Germany |
| **DK** | Denmark |
| **DLBK** | German Food Code (*Deutsches Lebensmittelbuch*) |
| **DLMBK** | German Food Code Commission (*Deutsche Lebensmittelbuchkommission*) |
| **DWA** | German Water Association (*Deutsche Vereinigung für Wasserwirtschaft, Abwasser, und Abfall e.V.* (formerly *Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, DVWK*)) |
| **EAP** | Environment Action Programme |
| **EC** | Ecuador |
| **e.g.** | Exempli gratia (for example) |
| **EG** | Egypt |
| **eq.** | equivalent |
| **ES** | Spain |
| **EU** | European Union |
| **EVS** | Income and Expenditure Survey of the Federal Statistical Office |
| **FAO** | Food and Agriculture Organization of the United Nations |
| **FLI** | Friedrich-Loeffler-Institut—Federal Research Institute for Animal Health (*Friedrich-Loeffler-Institut, Bundesforschungsinstitut für Tiergesundheit*) |
| **FR** | France |
| **GB** | Great Britain |
| **German WPP** | Waste Prevention Programme of the German government with the involvement of the Federal Länder (*Abfallvermeidungsprogramm des Bundes unter Beteiligung der Länder*) |
| **GLO** | Global |
| **ha** | Hectare |
| **HU** | Hungary |

| | |
|---|---|
| **I** | Inhabitant |
| **ID** | Indonesia |
| **i.e.** | Id est (that is) |
| **IE** | Ireland |
| **IED** | Industrial Emissions Directive |
| **IFG** | Federal Act Governing Access to Information held by the Federal Government (Freedom of Information Act, *Informationsfreiheitsgesetz*) |
| **IHC** | In home consumption |
| **IL** | Israel |
| **IT** | Italy |
| **kg** | Kilogram |
| **km** | Kilometer |
| **km²** | Square kilometer |
| **KrW-/AbfG** | Waste Avoidance, Recycling and Disposal Act (*Kreislaufwirtschafts- und Abfallgesetz*) |
| **KrWG** | Circular Economy Act (*Kreislaufwirtschaftsgesetz*) |
| **kW** | Kilowatt |
| **LAI** | Working Group of the Federal Government and the States on Immission Control (*Bund/Länder-Arbeitsgemeinschaft für Immissionsschutz*, LAI) |
| **LAV** | Working group on consumer protection (*Länderarbeitsgemeinschaft Verbraucherschutz*) |
| **LCA** | **life cycle assessment** |
| **LFGB** | Food and Feed Law (*Lebensmittel- und Futtermittelgesetzbuch*) |
| **m** | Meter |
| **m²** | Square meter |
| **m³** | Cubic meter |
| **MA** | Morocco |
| **MS** | Member State/s (of the European Union) |
| **MVwV** | Model administrative regulations (*Musterverwaltungsvorschriften*) |
| **NL** | The Netherlands |
| **OHC** | Out of home consumption |
| **PK** | Pakistan |
| **PL** | Poland |
| **ProdHG** | Act on Liability for Defective Products (Product Liability Act, *Produkthaftungsgesetz*) |
| **ProdSG** | Act on making products available on the market (Product Safety Act, *Produktsicherheitsgesetz*) |

| | |
|---|---|
| **RoW** | Rest of the World |
| **SCP/SIP Action Plan** | Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan |
| **SRU** | German Advisory Council on the Environment (*Sachverständigenrat für Umweltfragen*) |
| **SZ** | Swaziland |
| **t** | Ton |
| **TH** | Thailand |
| **TR** | Turkey |
| **UBA** | German Federal Environment Agency |
| **UIG** | Environmental Information Act (*Umweltinformationsgesetz*) |
| **UK** | United Kingdom |
| **UStatG** | Environmental Statistics Act (*Umweltstatistikgesetz*) |
| **UVPG** | Environmental Impact Assessment Act (*Gesetz über die Umweltverträglichkeitsprüfung*) |
| **VDI** | The Association of German Engineers (*Verband Deutscher Ingenieure*) |
| **VIG** | Consumer Information Act (*Verbraucherinformationsgesetz*) |
| **VSMK** | Conference of Consumer Protection Ministers (*Verbraucherschutzministerkonferenz*) |
| **WFD** | European Waste Framework Directive |
| **WPP** | Waste Prevention Programme |
| **WRAP** | Waste and Resources Action Programme |

# 1 Context of the project

In recent years the issue of food waste has increasingly become a topic of discussion. The documentary "Taste the Waste" was screened in 2011, and its alarming statements ("half of all food is thrown away") provoked public outrage about the way we deal with food. The same year, the Food and Agriculture Organization of the United Nations (FAO) published data about global food waste according to which roughly one-third of all food produced globally is discarded. That amounts to 1.3 billion tons of food per year.[1] At the same time, the FAO estimates that 925 million people worldwide suffer chronic hunger.[2]

The Federal Ministry of Food, Agriculture, and Consumer Protection published a study on food waste in Germany in 2012 which showed that approx. 82 kg of food are wasted per person per year in private households.[3]

Waste can be generated along any product life cycle, and this is also true of the production and use of food. The longer and the more complex such value-added chains are, the more numerous the possible places where wastes and losses can occur. In the case of food, this is no different from the situation with other "products": from original agricultural production to manufacturing and processing to wholesaling and retailing to end users in home or out of home.

A specific feature of food is that it is relatively perishable and thus requires particularly careful handling. If long distances need to be overcome from the place of production to the places of processing and consumption, which is commonplace in today's globalized world, then this also entails long time periods. For this reason, it is often necessary to cool food or to use substances that halt the ripening process. In short: Expert knowledge and appropriate equipment, but also careful handling, are essential for safe, and thus also low-waste, warehousing and distribution logistics for food.

This preconditions are not in place in equal measure around the world. So it is not surprising that in developing and newly industrializing countries, food waste occurs in particular along the distribution chain from the place of manufacture to the place of consumption. In middle- and high-income countries such as Germany, in contrast, food waste occurs especially in agriculture and at the place of consumption itself, but less along the path from food manufacture to consumers.[4] Besides the differences outlined above, the reasons for this include differences in the climate, but also different dietary habits and consumer behavior as well as at times lesser appreciation of food in industrialized countries.[5]

Against the background of the guiding principle of sustainable nutrition,[6] discarding food is above all an ethical problem: While people are starving to death in other parts of the world, we throw foods away that could perfectly well be eaten. But the environmental impacts of food production also play an important role. Here, the consequences of intensive agriculture, such as monocultures or pesticide use, dominate public perception, while other aspects, e.g., the climate effects of animal husbandry and the large number of transports, tend to be discussed more by experts.

---

1 Gustavsson et al. 2011.

2 http://www.fao.org/mdg/goalone/en/; last accessed 8 August 2012.

3 Kranert et al. 2012.

4 Cf. Gustavsson et al. 2011.

5 Cf. also: Gustavsson et al. 2011 as well as Rosenbauer 2011.

6 "A sustainable diet is environmentally compatible, promotes health, is ethically responsible and appropriate to everyday life, and enables sociocultural diversity" (Eberle; Hayn 2007).

One of the most important ways to achieve more responsible handling of food is to increase appreciation of food and nutrition overall. Many different factors facilitate people in our country discarding food easily.

One factor is the constantly declining percentage of the available household budget that has to be spent on food. This figure has been dropping continuously since the 1960s. Today, food accounts for less than 15% of private households' consumption expenditures.[7]

The overabundance of food and the availability of practically all products year-round are additional contributing factors. The fact that grocery store shelves are fully stocked all day long, including with fresh products, contributes to the growing amounts of food waste.

The increasing alienation of consumers from how food comes into being also plays a role. In particular decreasing knowledge about nutrition, especially about proper storage and preparation of food, as well as the low societal appreciation of labor associated with food, are relevant for the high percentages of discarded food.[8]

If an important key to reducing food waste lies in increasing appreciation for nutrition and food, and thus for the labor associated with it, then it is necessary to impart competences in handling food as well as knowledge about how food is produced and manufactured, and about when and where which products are in season, among other things. In contrast, discount and full-range supermarkets continually underbidding each other's food prices, XXL menus for away-from-home consumption, and advertising using illusory images of idyllic farms that have not existed for a long time and presumably never existed tend to be more counterproductive.

Against the background of what has been outlined above, it becomes clear that the problem of food waste should also always be considered in the context of developing strategies for sustainable development overall.

Parallel to the longstanding discussion about a sustainable diet (or a "diet transition") outlined above and the moral and ethical questions concerning our wasteful way of dealing with food, which periodically receive more public attention, the topic has also come into focus in the course of the revision of the European Waste Framework Directive[9] (WFD).

The placement of waste prevention at the top of the waste hierarchy, which was confirmed by the Directive, as well as the associated obligation set out in Art. 29 WFD for Member States to establish waste prevention programmes, intensified the discussion about existing waste prevention potentials. [10] This includes food waste.

In July 2013, the German federal government adopted a "Waste prevention programme of the German government with the involvement of the Federal Länder"[11] on the basis of scientific

---

7 Cf. Hünecke et al. 2004.

8 See also: Eberle 2006.

9 Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Waste Framework Directive), published in the Official Journal of the European Union No. L 312 p. 3, corrected Official Journal of the European Union No. L 127, p. 24.

10 An overview of the status of these waste prevention programmes in the various Member States is available at http://scp.eionet.europa.eu/facts/WPP.

11 Cf. Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2013): Waste prevention programme of the German government with the involvement of the Federal Länder, July 2013.

background studies[12] and following hearings with stakeholders, in order to implement § 33 Circular Economy Act (KrWG).[13]

In this program, the federal government makes the following concrete recommendation concerning food waste: “With a view to preventing food waste, concerted actions and agreements between public institutions and industry/trade are to be encouraged in order to minimize food waste occurring along the production and supply chain. The goal is to take the entire value-added chain—i.e., not only consumer behavior—into account in order to reduce food waste.” [14]

[12] Esp. Dehoust et al. 2013.

[13] Act to Promote Circular Economy and Safeguard the Environmentally Compatible Management of Waste (Closed Substance Cycle and Waste Management Act), 24 February 2012, BGBl. I, p. 212, last amended by § 44 Para. 4 of the Act of 22 May 2013 (BGBl. I, p. 1324).

[14] Ibid., Section 4.1. Recommended measures, p. 30.

# 2 Goals and approach of the project

Against the background of the context outlined above, this research project is to make a contribution to the discussions around the occurrence of food losses and their prevention from the perspective of environmental protection.

For this reason, the environmental impacts due to food losses are described qualitatively, evaluated, and quantified in the first section to obtain a robust assessment of the environmental relevance of waste prevention activities in this area. The results of this assessment of the environmental relevance serve both to support communication about food waste prevention efforts and to provide objective reasons for waste prevention measures.

In the second part of the project, possible binding prevention measures from the field of environmental law are derived and reviewed. The goal here is to identify measures suitable for updating the waste prevention programme.

In order to be able to implement these different goals while carrying out the project, the various aspects were dealt with, largely in parallel, in the following work packages:

- WP 1: Validation of the numerical data
- WP 2: Determination of the environmental impacts
- WP 3: Derivation and review of measures.

During the work on each of the three work packages, expert meetings[15] were held in the course of which key questions and the authors' working hypotheses were discussed with a circle of selected experts.

In the present report, the results are presented in a more content-related manner and independently of this structure of managing the project.

Chapter 3 includes the description of the basic methodology and an overview of the numerical data on which the assessment of the environmental impacts is based as well as the results of the assessment of the environmental impacts of food losses. The details concerning the data sources of the calculations performed etc. are documented in a separate report.

In Chapter 4, both the approach taken by the authors of the present report when evaluating measures proposed in existing secondary studies and the development of further appropriate measures are presented on the basis of a review of the opportunities provided by existing legal instruments. The authors evaluate measures and derive recommendations for measures on this basis

Chapter 5 presents the authors' conclusions and recommendations.

# 3 Assessment of the relevance of food losses

## 3.1 Requirements, approach and explanation of case studies

### 3.1.1 Definitions and specifications

In contrast to a legal perspective, the ecological viewpoint identifies “food waste” as those parts of a foodstuff which in the course of its life cycle – i.e. from agricultural production

[15] Workshop "Numerical data on food waste" on 15 February 2012 at Ökopol GmbH in Hamburg; workshop "Environmental impacts of food waste" on 14 May 2013 at the Federal Environment Agency in Berlin; workshop "Food losses and food law" on 4 April 2014 at Leuphana University of Lüneburg.

through processing and trade to consumers - are not used for human consumption. This includes raw goods which are left on the fields and are not harvested as well as losses in food processing which are not put to any other use, and leftovers at home. Also included are food scraps that are unfit for consumption such as banana skins, or cannot be consumed due to the type of preparation, such as potato peelings in the preparation of boiled potatoes. The term "**food losses**" is therefore used in the assessment of the environmental relevance for the sake of clarity and in contrast to "waste" used in contexts of environmental law.

This study does not differentiate between "avoidable" and "unavoidable" food losses, unlike other studies such as Kranert et al. (2012). The reasoning is that a clear classification is not always feasible (to which extent are potato peelings avoidable or unavoidable food loss?); moreover, the classification in "avoidable" and "unavoidable" is an inherent assessment based on a value system which rates certain eating habits as "normal".

Since the primary goal of waste prevention is to avoid resource utilization for the making of products that subsequently are not used as intended, this environmental impact is in the focus of considerations.[16] It was agreed with the client to exclusively consider the environmental impact of the creation and production of foodstuff but not the impact of packaging also required and disposed of.[17] The study does not include beverages since only few environmentally relevant data are available for them, nor any volume-based breakdown by types of beverages. Confectionary products are not included since they are no basic foods.

### 3.1.2 Requirements for assessment of environmental impact due to food losses

Foods are traded worldwide. Raw, intermediate or end products are traded beyond national borders at almost all levels of the value chain. This implies that losses of foodstuff or agricultural products may occur at all levels.

A material flow analysis[18] is conducted in this study in order to account for the environmental impact of food losses. The material flow analysis methodically explores material flows based on demand, i.e. the utilization of food by consumers, and traces them back via subsequent levels of finishing and refinement to the point of resource extraction, i.e. the agricultural production of food.

This requires above all an analysis of the material flows of our food consumption; for example, where does the food we consume come from? Which volumes are produced? Where do losses occur, and in which quantities?

This means that an assessment of environmental implications requires the definition of a reference point within the entire material flow from which to conduct the accounting in order to set the system boundaries.

---

[16] Moreover, it is difficult to operationalize an assessment of the additional environmental impact and of relief factors from food waste disposal for the entire range of relevant waste streams. In the primary and pre-production of food, the major part of food losses takes various utilization paths, some with cascading levels. This would require a broad assessment of secondary products. Losses from distribution and end use (trade, OHC and IHC) also enter a wide and unspecific spectrum of recovery and disposal operations (from home composting and biological-mechanical processes to waste incineration), all of which would require separate assessment.

[17] Disposal of packaging together with food produced for consumption has certainly an additional environmental impact. But this study does not include packaging nor the environmental impact of packaging of food losses.

[18] The material flow analysis serves to determine which material flows and environmental burdens are caused by the **demand** for products and services. All relevant production and distribution expenditures are quantitatively traced back to source (resource extraction). It also permits to consider effects abroad (imports) and special regional aspects (Fritsche, Eberle 2007: p. 2f).

The objective is to assess the environmental impact from food losses due to inland demand for foods. The material flow model associates the demand with the two places where food is primarily consumed:

- consumption of food in home (in-house consumption / IHC), and
- consumption of food in restaurants, cafes, fast food places and individual catering, or in communal catering (canteens)(out-of-home consumption / OHC).

Research of material flows is therefore conducted from these two perspectives. Taken together they illustrate the consequences for our environment resulting from our entire food consumption, i.e. actual consumption and losses.

### 3.1.3 Explanation of case studies

One aim is to answer the question about the extent of the environmental impact caused by food losses due to the demand by German consumers for food (IHC and OHC). Another is to determine the environmental impact on the basis of some case studies. These may subsequently be used to illustrate the environmental implications of food losses.

The following three case studies are analyzed in the context of the project:

**1. Case study asparagus**

The case study on asparagus provides an exemplary balance sheet of the environmental impact resulting from the cultivation, processing and distribution of a specific foodstuff. Asparagus is a product of regional culinary culture with well-known growing areas in Germany (Schwetzingen, Beelitz, heathland asparagus) and remoter regions (Italy, Greece, Peru). The season for asparagus, depending on climate and weather conditions, traditionally goes from middle/end of May to St John's Day (24 June). The following aspects of waste generation may be illustrated on the basis of this example:

- environmental effects at various levels along the value chain,
- various environmental effects due to in-season and out-of-season supply requiring different transport routes: regional asparagus in the season vs. out-of-season asparagus transported to Germany by truck from Greece (March/April) and/or by air or sea from Peru (e.g. around Christmas),
- various environmental effects due to different cultivation techniques (outdoor vs. heated cultivation)
- exemplary display of avoidable and unavoidable losses.

**2. Case study marketing formats**

The case study explores potential quantitative differences of food losses and, as a consequence, different environmental effects due to different marketing formats. This is investigated using the example of tomatoes offered loose or in small packages.

**3. Case study kitchen management and format of presentation in OHC**

The case study explores the potential environmental effects of a reduction of food waste in out-of-home consumption due to improved kitchen management, e.g. with different formats of presentation (meals handed out at food counter vs. buffet), and potential effects of changes in the composition of food waste (e.g. less waste of particularly environment-intensive products such as meat or dairy products).

## 3.2 Estimation of environmental effects

Food waste created by the demand for food in Germany may occur within Germany and also outside, depending on the place of production for food consumed in Germany. Accordingly, the related environmental effects occur either in Germany and/or other countries, depending on where the food is produced which is wasted here. This analysis of the demand side permits a statement on environmental effects due to food losses which are related to the demand for food on the part of German consumers. However, it does not answer the question about the extent of the environmental impact as a consequence of all food losses in Germany. The agricultural sector and the food processing industry do not produce for the German market exclusively. Part of agricultural and processed products is exported. Environmental effects of food losses resulting from these exported products are therefore not included in this analysis.[19]

The balancing procedure is based on the perspective of consumer demand at two places:

- in the private household (in-home consumption / IHC),
- outside the home in individual and system catering (e.g. restaurants, fast food places) and communal catering (canteens) (out-of-home consumption / OHC).

### 3.2.1 Balancing techniques and approach

Several methods serve to assess environmental effects of products and systems. Key methods are life cycle assessment (LCA) and material flow analysis.

The LCA is the first tool for the analysis of environmental effects to be scientifically designed internationally and standardized at national and international levels (ISO 14040 and ISO 14044).[20]

According to the standard, a LCA comprises four stages:

1. Definition of objective and scope of analysis
2. Life cycle inventory
3. Impact assessment: evaluation of environmental impact of considered indicators (e.g. greenhouse effect, acidification, ozone depletion, eco-toxicity)
4. Interpretation

Material flow analyses developed in parallel to LCA in the late 1980s and early 1990s are far more flexible. Unlike LCA, no standard applies to determine procedures in material flow analyses.

As described above, the material flow analysis is a suitable method for the purposes of the project to illustrate the environmental impact of food losses caused by food demand in Germany.

Since the demand for food and resulting food losses are not caused by a single foodstuff but by the entire shopping basket of food demanded by consumers, the material flow analysis requires

[19] But it is possible to extrapolate at least those environmental effects of food losses which occur in the food processing industry and trade (cf. chapter 3.3.2).

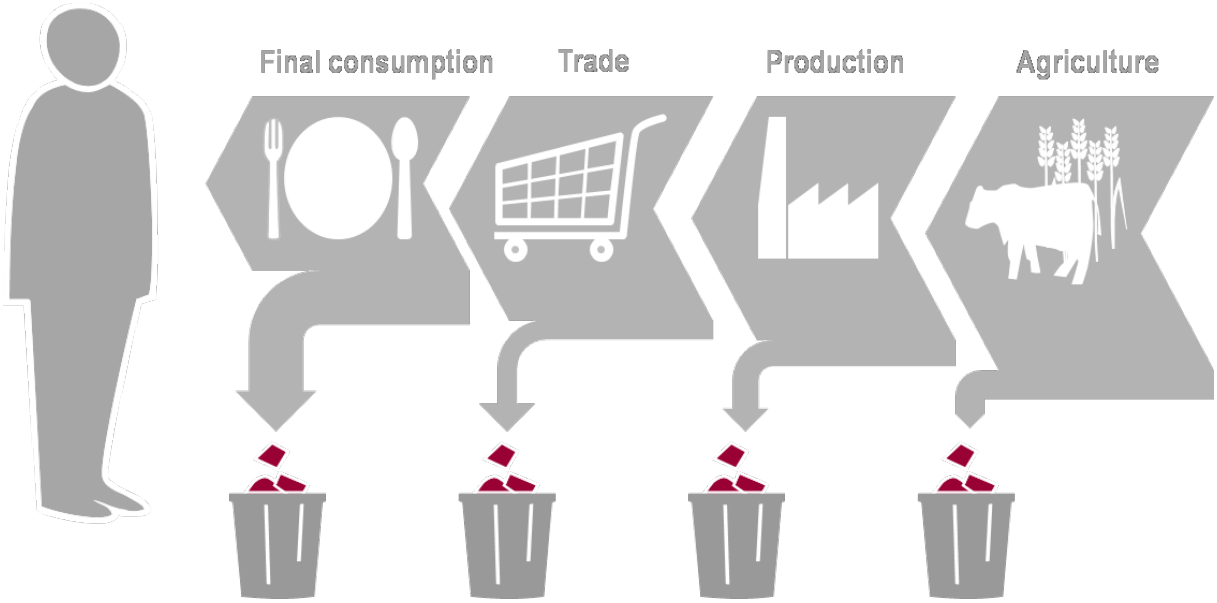
[20] Translated from Wiegmann et al. 2005a: p.4: “The term ‘balance’ is not to be understood in bookkeeping terms but illustrates that the analysis strives to comprise all material and energy flows which enter and leave the system. The eco-balance aims to identify ecological deficits of the systems under analysis and offer recommendations to optimize them. It is the only eco-assessment tool with the capacity to evaluate complex systems.”

to trace back the life cycle of products contained in the food shopping basket[21] to their origin in agricultural production.

In balancing the environmental impact from the perspective of food demand (OHC/IHC), those environmental effects are illustrated which are generated along the life cycle of discarded food. They are generated e.g. by the storage of food and preparation of meals in or outside the home, shopping trips and transport of goods, the provision of products for trade, by the processing and agricultural production of raw goods.

The starting point for the analysis is the food consumed annually, with the shopping basket of food as a reference. Taking this as a basis, food losses are added up that occur on previous stages (trade, processing and agricultural production). Figure 1 illustrates this approach.

Figure 1: Approach for analyzing the environmental impact




Source: own research.

These different product life cycles have structures of diverse complexity. It is comparably simple to trace back the cycle of a potato produced in Germany and consumed in the home or discarded. As a rule it is purchased from food retailers who get it from wholesalers. The potato reaches the wholesale trade directly from agricultural production (cooperatives or individual farmers) without processing. Direct sales from the farm skip the wholesale trade to some extent.

The first question to research in this example would be which amounts of potatoes are discarded in private homes, which amounts are wasted in retail and wholesale trade, and which losses occur in farming. A balance sheet of environmental impact requires additional information on how the potato is stored and prepared at home, distance and type of shopping trip and of transport to trade, and how much energy is used for the potato in trade. And not least: information is required how the potato has been grown, i.e. data on energy consumption for field work, amounts of fertilizers and pesticides, water consumption for irrigation and land required for cultivation.

[21] For the purposes of this study, the food shopping basket describes the annual average food consumption per person in Germany.

But not all potatoes consumed in Germany are grown here; a certain percentage is imported from abroad. This means the amounts imported from each country need to be researched as well as the environmental impact of agricultural production in these countries and the means of transporting potatoes to Germany.

Apart from such relatively simple life cycles, there are far more complicated product life cycles, e.g. the production of cheese or meat. Let us take cheese production as an example. Above-mentioned parameters are data on storage and preparation in home or in OHC and energy consumption for trade and transport; but production comprises at least one further processing stage, i.e. the processing of milk. Agricultural production is also more complex for cheese: the milk cow requires feed which needs to be grown as well (e.g. grass, grain) and in some instances requires further processing (e.g. soybean meal from soybeans must be ground). Moreover, dairy cows produce milk only after calving at least once. All this must also enter the balance sheet for cheese production. A so called allocation is necessary at this point, i.e. the environmental impact must be assigned to the co-products calf and milk. And another necessary consideration is that cheese consumed in Germany is not exclusively produced here.

As outlined above, it is a complex undertaking to draw up a balance sheet for the environmental impact of food losses connected with food consumption in Germany, and therefore a number of simplifications must be made in some respects. The following section describes the scope of the study (chapter 3.2.2), the underlying quantity structure (chapter 3.2.3), the environmental data used (chapter 3.2.4) and the modelling including simplifications (chapter 3.2.6).

## 3.2.2 System boundaries and method of impact assessment

### 3.2.2.1 System boundaries

System boundaries describe processes that are included in the study (within the system boundaries) and those which remain unconsidered (outside the system boundaries).

For the purposes of the study, the following processes are within system boundaries:

- food consumption in Germany (IHC and OHC): shopping trips or transport from trade to OHC, storage, preparation
- trade: energy and refrigerant consumption in wholesale and retail trade, transport from wholesaler to retailer
- processing: energy and refrigerant consumption, transport to retailer
- agricultural production: consumption of energy, fertilizers, pesticides and water for irrigation, land use for herbal food and feed; where applicable: energy and feed use in livestock farming; transports to processing plants

The following processes are outside system boundaries:

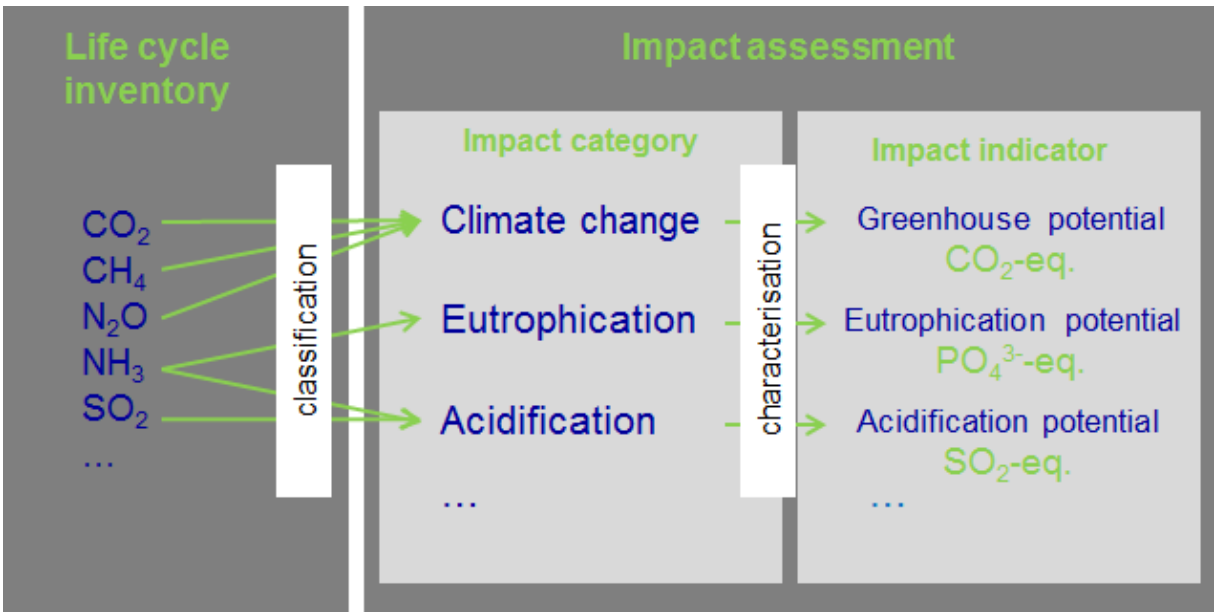
- production of seed
- use of water and land outside agricultural production (data not consistently available)
- waste recycling and disposal
- food packaging (product package and re-packaging)

### 3.2.2.2 Impact assessment

For impact assessment, the results from the life cycle inventory - i.e. the individual material flows entering and leaving the system (input and output) are assigned to so called environmental impact categories, and their potential impact is calculated. Individual inputs and outputs are characterized in relation to a reference substance for a calculation of the impact potential.

For example, carbon dioxide ($CO_2$) is the reference substance in the impact category "greenhouse effect". The potential greenhouse impact of all other global warming gases such as methane, nitrous oxide, hydrofluorocarbons and perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride, is now expressed in relation to $CO_2$. The greenhouse potential of methane for example is 25 times that of $CO_2$, of nitrous oxide even 298 times higher. These specific greenhouse potentials are multiplied by the quantity of the respective greenhouse gas and then aggregated into the greenhouse potential in terms of $CO_2$ equivalents. Analogous procedures are applied in other environmental impact categories (see Figure 2).

Figure 2: Impact assessment




Source: own research.

A variety of different techniques are applied for the purposes of impact assessment. The method used in this study is the well-established ReCiPe Midpoint[22].

The following environmental impact categories from ReCiPe Midpoint are considered in the analysis:

- climate change, i.e. greenhouse effect or greenhouse potential, expressed in carbon dioxide equivalents ($CO_2$ equivalents)
- fossil depletion, expressed in crude oil equivalents
- freshwater eutrophication, expressed in phosphor equivalents (P equivalents)
- marine eutrophication, expressed in nitrogen equivalents (N equivalents)
- metal depletion, expressed in ferric equivalents (Fe equivalents)
- ozone depletion, expressed in trichlorofluoromethane equivalents (CFC11 equivalents)
- particulate matter formation, expressed in particulate matter equivalents (PM equivalents)
- photochemical oxidant formation, expressed in non-methane hydrocarbon equivalents (NMVOC equivalents)
- terrestrial acidification, expressed in sulphur dioxide equivalents ($SO_2$ equivalents)

[22] Goedkoop et al. 2009.

In addition, the use of agricultural land and water consumption for irrigation – so called "blue water"[23] is recorded at the level of agricultural production.

### 3.2.3 Quantity structure of food losses

The first step for a balance sheet of environmental impact from food losses is to set up a quantity structure for food losses at the various stages of the life cycle. This structure must permit differentiation not only by life cycle stages but also by products.

Research and discussions with experts during two workshops in February and May 2013 revealed that the data actually required for a balance sheet of environmental impact are only available to a limited extent. There is an almost complete absence of waste quantity flows categorized by individual products; only product groups can be recorded. For some life cycle stages, e.g. processing, only estimations are available even for total quantities. The study by Kranert et al. 2012, for example, quotes food losses in the processing stage of 210,000 tons up to 4.58 million tons without a differentiation for product groups.

As a consequence of a lack of specific data, plausible assumptions must be made in some instances for the quantity structure, e.g. with regard to the distribution of food losses across foodstuffs.

It must also be noted, however, that on the side of LCA there are no complete data on environmental impact available for all products of the German food shopping basket (cf. chapter 3.2.4), so that an iterative method was chosen at this point. The quantity structure was drawn up on the basis of available data and in dependence on the availability of environmental data of foodstuffs to be analyzed.

Major publications on food losses used as a basis for the quantity structure of this study are the following:

- Kranert et al. 2012
- Peter et al. 2013
- Gustavsson et al. 2011

An ITAS (Institut für Technologiefolgenabschätzung und Systemanalyse) study [24] gives a current overview of studies on food losses conducted in Europe in recent years.

The quantity data on food losses from the study by Kranert et al. 2012 are the most up-to-date and valid data currently available in Germany, as confirmed by experts at the two workshops in 2013. The quantity structure for this project is therefore based on these data.

However, Kranert et al. 2012 exclusively analyze food losses after agricultural production. Data for agricultural production must therefore be supplemented by findings from other studies and statistics.

The authors use the loss rates quoted in the FAO study[25] for this purpose at the level of agricultural production. They accept that the definition of food losses in that study does not correspond to 100% to the definition chosen here. Therefore they cannot exclude the possibility that losses which should be included according to the definition chosen here are not included in the FAO loss rates. But they rate the resulting potential deviation as insignificant.

---

[23] Cf. Mekkonen; Hökstra 2010.

[24] Priefer; Jörissen; Bräutigam 2013: p. 15ff.

[25] Gustavsson et al. 2011

The study by Gustavsson et al. 2011 defines food losses as follows:

"Food losses refer to the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption. Food losses take place at production, postharvest and processing stages in the food supply chain (...). Food losses occurring at the end of the food chain (retail and final consumption) are rather called "food waste", which relates to retailers' and consumers' behavior (...)."[26]

FAO data are also used for postharvest handling and for losses in the food industry. The study by Kranert et al 2012 has only fragmentary information for this aspect, since the participation of the food sector in the respective survey was very low (<4%).

In contrast, the study by Peter et al. 2013 provides a detailed analysis of postharvest losses for potatoes, apples and wheat in Germany.

Loss rates in food retailing are based on figures from the study by Kranert et al. 2012. But since these are very low compared to other countries (the study indicates a maximum value that is more than five times higher than the median)[27], a sensitivity analysis explores possible changes in results if different loss rates are used as a basis (cf. chapter 3.3.2.2). Loss rates in wholesale trade are also based on the study by Kranert et al. 2012.

Loss rates given by this study are also used to calculate the figures for domestic households. Since data are available not for individual products but for product groups at the domestic household level, these had to be converted to products. This is done on the basis of the German consumer shopping basket as quoted in the national Income and Consumption Survey (Federal Statistical Office 2010).

Data from Kranert et al. 2012 were also used at the level of OHC. Neither this study nor publications from the sector[28] break down quantitative losses into product groups. Such a classification being required in the calculation of environmental impact, the reference used is the Income and Consumption Survey/Federal Statistical Office[29] on the one hand, and data from the BMBF (Federal Ministry for Education and Research) research project on Food Change referring to the distribution of consumption between IHC and OHC on the other.[30]

The aspects outlined above are summarized below and presented together with the quantity structure underlying the estimated environmental impact. Since the observation perspective in the material analysis is based on IHC and OHC, consumption and loss quantities are presented for these two locations of consumption. Taking these two demand categories as a background, losses incurred at the respective previous life cycle stage (trade, processing, agricultural production) are then added and presented as loss rates.

#### 3.2.3.1 Domestic food consumption and losses

For the domestic level, data on food consumption are derived from the most recent Income and Consumption Survey (EVS 2008) available at the time of the study. Figures on food losses from the study by Kranert et al. were calculated for products, based on the shopping basket as indicated in the EVS. The study by Kranert et al. quotes an average food loss of 6.1 million tons (cf. Table 3). Since environment-related data are not available for all products of the EVS shopping

[26] Gustavsson et al. 2011, p.2

[27] Kranert et al. 2012: p. 182

[28] Deutscher Fachverlag 2011

[29] Statistisches Bundesamt 2010

[30] Wiegmann et al. 2005b.

basket, some products are associated with others in this respect. Such cases are indicated in the table below under "comments". The table below illustrates the German food shopping basket in 2008[31]. It contains details on the quantities of purchased food, i.e. it covers foodstuffs consumed and discarded at domestic level.

Table 1: German food shopping basket 2008 (per capita and per year)

| Product group | Amount [kg/I*a] | Comments |
|---|---|---|
| **Bread & cereals** | **104.614** | |
| Rice | 2.395 | |
| Bread/bakery products | 79.212 | Bread and pastries |
| Pasta / further cereals | 23.007 | |
| **Meat / meat products** | 41.503 | |
| Beef and veal | 7.152 | incl. sheep, goat, further meat |
| Pork | 7.138 | incl. meat w/o exact designation |
| Poultry | 5.406 | |
| Meat products | 21.807 | incl. meat preparations |
| **Fish / processed fish products** | **5.485** | |
| Fish / processed Fish products | 5.485 | |
| **Dairy products & eggs** | **144.059** | incl. butter |
| Milk | 118.478 | incl. preserved milks and further products on basis of milk or cream, incl. yoghurt and cream cheese |
| Cheese | 9.840 | incl. cheese w/o exact designation |
| Cream | 4.062 | |
| Butter | 4.110 | |
| Eggs | 7.569 | |
| **Fats & oils** | **6.972** | w/o butter |
| Fats and oils | 6.972 | |
| **Fruits** | **60.290** | |
| Citrus | 9.900 | |
| Banana | 14.480 | incl. further tropical fruits |
| Apples | 32.958 | incl. pears, further stone fruit, and frits w/o exact designation, berries and grapes, dried fruits and nuts, seeds |
| Preserved fruits, frozen fruits | 2.952 | |
| **Vegetables & potatoes** | **87.897** | |

[31] Income and Consumption Surveys are conducted every five years. Data from 2013 had not been published at the time of the study.

| Product group | Amount [kg/I*a] | Comments |
|---|---|---|
| Tomatoes | 19.461 | incl. peppers, cucumbers, further fruit vegetables |
| Fresh vegetables, salad | 29.592 | all other vegetables |
| Dried, frozen and preserved vegetables | 12.726 | |
| Potatoes | 26.118 | |
| **Sugar** | **5.895** | |
| Sugar | 5.895 | incl. sweeteners |
| **SUM** | **456.715** | |

Source: own calculation based on EVS.

On the basis of these data, quantities of food losses in private homes (Table 2) are classified according to the various products of the respective product group as a next step. The procedure is as follows: based on data for average food losses of the respective food group, quantities are evenly distributed on the products of this group.

Table 2: Annual food losses in German households

| Product groups | Unit | Minimum | Average | Maximum |
|---|---|---|---|---|
| Bakery products | t/a | 748,585 | 861,275 | 973,965 |
| Meat and fish | t/a | 595,648 | 684,191 | 772,733 |
| Milk and dairy products | t/a | 595,648 | 684,191 | 772,733 |
| Fruits and vegetables | t/a | 2,575,776 | 2,962,142 | 3,348,509 |
| Home cooking and ready meals | t/a | 804,930 | 925,670 | 1,046,409 |
| **SUM** | **t/a** | **5,320,587** | **6,117,468** | **6,914,349** |

Source: according to Kranert et al.

No data are available on the elements making up food losses in the product group “home cooking and ready meals”. Therefore an assumption had to be made on their composition. Food losses were assigned to individual products based on the assumption that all products of the EVS shopping basket, with the exception of bread/baked goods and fresh fruit, were equally used for home cooking and ready meals. Bread and bakery products as well as fresh fruit were not considered since they are hardly ever used in the preparation of home-cooked or ready meals.

Table 3(below) illustrates the resulting food loss quantities in private households (per capita and year) and the percentage of food losses for individual products/product groups.

Table 3: In house food consumption, food eaten, food losses and food losses as shares of shopping basket

| Product group | consumption [kg/I*a] | Food eaten [kg/I*a] | Food losses [kg/I*a] | Loss to consumption [%] |
|---|---|---|---|---|
| **Bread & cereals** | **104.614** | **93.002** | **11.612** | **11.10%** |
| Rice | 2.395 | 2.309 | 0.086 | 3.59% |
| Bread/Bakery products | 79.212 | 68.512 | 10.700 | 13.51% |
| Pasta / further cereals | 23.007 | 22.181 | 0.826 | 3.59% |
| **Meat / meat products** | **41.503** | **32.505** | **8.999** | **21.68%** |
| Beef and veal | 7.152 | 5.602 | 1.551 | 21.68% |
| Pork | 7.138 | 5.591 | 1.548 | 21.68% |
| poultry | 5.406 | 4.234 | 1.172 | 21.68% |
| meat products | 21.807 | 17.079 | 4.728 | 21.68% |
| **Fish / processed fish products** | **5.485** | **4.295** | **1.189** | **21.68%** |
| Fish / processed Fish products | 5.485 | 4.295 | 1.189 | 21.68% |
| **Dairy products & eggs** | **144.059** | **130.384** | **13.674** | **9.49%** |
| Milk | 118.478 | 106.844 | 11.634 | 9.82% |
| Cheese | 9.840 | 8.874 | 0.966 | 9.82% |
| Cream | 4.062 | 3.663 | 0.399 | 9.82% |
| Butter | 4.110 | 3.706 | 0.404 | 9.82% |
| Eggs | 7.569 | 7.297 | 0.272 | 3.59% |
| **Fats & oils** | **6.972** | **6.722** | **0.250** | **3.59%** |
| Fats and oils | 6.972 | 6.722 | 0.250 | 3.59% |
| **Fruits** | **60.290** | **45.212** | **15.078** | **25.01%** |
| citrus | 9.900 | 6.880 | 3.020 | 27.27% |
| banana | 14.480 | 10.064 | 4.417 | 27.27% |
| apples | 32.958 | 24.634 | 8.324 | 25.26% |
| preserved fruits, frozen fruits | 2.952 | 2.846 | 0.106 | 3.59% |
| **Vegetables & potatoes** | **87.897** | **62.912** | **24.985** | **28.43%** |
| Tomatoes | 19.461 | 13.111 | 6.350 | 32.63% |
| Fresh vegetables, salad | 29.592 | 19.936 | 9.656 | 32.63% |
| Dried, frozen and preserved vegetables | 12.726 | 12.269 | 0.457 | 3.59% |
| Potatoes | 26.118 | 17.596 | 8.522 | 32.63% |
| **Sugar** | **5.895** | **5.684** | **0.212** | **3.59%** |
| Sugar | 5.895 | 5.684 | 0.212 | 3.59% |
| **SUM** | **456.715** | **380.715** | **76.000** | **16.64%** |

Source: own calculation; rounded last decimal places may result in minor discrepancies in totals.

#### 3.2.3.2 Food consumption and losses in out-of-home consumption

At the level of out-of-home consumption (OHC), food consumption is calculated from data provided by Wiegmann[32]. The assumption is that the shares of total consumption are the same as at the time of the study. OHC quantities are calculated on the basis of EVS data for domestic consumption. The reason for this assumption is that no quantities (analogous to EVS) are available for OHC. Data on food losses in OHC are taken from the study by Kranert et al. which quotes an average loss of 1.9 million tons of food.

Distribution among products follows a two-step process:

- Distribution of consumption into IHC and OHC for individual products / product groups was obtained from the BMBF research project "Ernährungswende"[33].
- This distribution, together with the German food shopping basket from the latest EVS (2008, cf. Table 1), serve as references to calculate the food quantities purchased in OHC.

The table below shows the results.

Table 4: Food losses in out of home consumption

| Product group | consumption [kg/I*a] | Food eaten [kg/I*a] | Food losses [kg/I*a] |
|---|---|---|---|
| **Bread & cereals** | **28.295** | **18.818** | **9.478** |
| Rice | 0.721 | 0.479 | 0.241 |
| Bread/Bakery products | 20.650 | 13.733 | 6.917 |
| Pasta / further cereals | 6.925 | 4.605 | 2.319 |
| **Meat / meat products** | **9.820** | **6.531** | **3.289** |
| Beef and veal | 2.707 | 1.801 | 0.907 |
| Pork | 2.702 | 1.797 | 0.905 |
| poultry | 2.046 | 1.361 | 0.685 |
| meat products | 2.364 | 1.572 | 0.792 |
| **Fish / processed fish products** | **2.076** | **1.381** | **0.695** |
| Fish / processed Fish products | 2.076 | 1.381 | 0.695 |
| **Dairy products & eggs** | **7.902** | **5.255** | **2.647** |
| Milk | 5.650 | 3.757 | 1.892 |
| Cheese | 0.770 | 0.512 | 0.258 |
| Cream | 0.220 | 0.146 | 0.074 |
| Butter | 0.196 | 0.130 | 0.066 |
| Eggs | 1.067 | 0.710 | 0.357 |
| **Fats & oils** | **6.972** | **4.637** | **2.335** |
| Fats and oils | 6.972 | 4.637 | 2.335 |

[32] Wiegmann et al. 2005b

[33] Wiegmann et al. 2005b

| Product group | consumption [kg/I*a] | Food eaten [kg/I*a] | Food losses [kg/I*a] |
|---|---|---|---|
| **Fruits** | **2.441** | **1.624** | **0.818** |
| citrus | 0.406 | 0.270 | 0.136 |
| banana | 0.593 | 0.395 | 0.199 |
| apples | 1.351 | 0.898 | 0.452 |
| preserved fruits, frozen fruits | 0.091 | 0.061 | 0.031 |
| **Vegetables & potatoes** | **12.776** | **8.497** | **4.279** |
| Tomatoes | 2.012 | 1.338 | 0.674 |
| Fresh vegetables, salad | 3.060 | 2.035 | 1.025 |
| Dried, frozen and preserved vegetables | 4.460 | 2.966 | 1.494 |
| Potatoes | 3.244 | 2.158 | 1.087 |
| **Sugar** | **0.188** | **0.125** | **0.063** |
| Sugar | 0.188 | 0.125 | 0.063 |
| **SUM** | **70.471** | **46.866** | **23.605** |

Source: own calculations. Rounded last decimal places may result in minor discrepancies in totals. The proportion of losses is not given in this table since it always amounts to 33.5%, due to the method used.

The calculation illustrates that the percentage losses in OHC with one third considerably exceed those incurred in IHC (cf. Table 3). However, it is important to note that the quantity structure for out-of-home consumption is not based on statistical data.

Recent studies at the Münster University of Applied Sciences indicate losses of between 8 and 30 % for communal catering[34]. Other studies also suggest lower rates compared to international studies.[35] But it remains unclear in how far they include unavoidable food losses, as has been done in this study.

In total, it appears that a better and more reliable database would be necessary for out-of-home consumption. Explorations analogous to the EVS for domestic consumption would be desirable.

#### 3.2.3.3 Food losses in trade

At the level of trade, the study explores food wholesalers and retailers. Accordingly, losses need to be differentiated between wholesale and retail trade. This study uses the loss rates of the EHI Retail Institute as a basis to which Kranert et al. also referred to in their study (table 9). Data provided by the EHI Retail Institute, however, only refer to supermarkets exclusively[36]. No data are available on food losses in discount food retailers[37]. This means that assumptions

[34] Blumenthal; Göbel 2014.

[35] Priefer; Jörissen 2012.

[36] Supermarkets or full-range providers are food retailers which offer the entire range of food products, as a rule complemented by non-food articles. Examples in Germany: Edeka, REWE and Real stores (source: http://wirtschaftslexikon.gabler.de/Archiv/124957/supermarkt-v5.html)

[37] Discount food retailers are food retailers characterised by permanently low price levels and limited assortments (in contrast to full-range providers) and low service levels. Examples in Germany: Aldi, Lidl, Netto (source: http://wirtschaftslexikon.gabler.de/Archiv/121133/discounter-v6.html)

must be made for loss rates in discounters. Kranert et al. assume that loss rates in discounters are lower compared to supermarkets in view of the more limited product range, specifically for fresh and perishable foodstuffs. The authors assume loss rates for discounters that are about 50% lower than those in supermarkets. The sales share of discounters in German food retailing is given as 44.8%.[38] Loss rates used in the study by Kranert et al. are also used as a basis in this study.

It was not possible to consider the different loss rates for bread and bakery products from self-service shelves and baking stations as quoted by Kranert et al. in the quantity structure for this product, since environment data do not differentiate between these two formats of provision. The EHI Retail Institute quotes higher loss rates for the self-service section. For the purpose of a conservative assumption the value indicated is also considered to apply to the backing station. The following loss rates result for the food retailing sector:

Table 5: Loss rates in food retailing

| Product groups | losses in % of turnover (total food retail) | | |
|---|---|---|---|
| | Minimum | Average | Maximum |
| Fruits and vegetables | 2.64% | 3.97% | 5.51% |
| Meat/sausage/fish/poultry | 0.52% | 1.63% | 2.58% |
| Milk and dairy products | 0.68% | 1.20% | 2.58% |
| Bread and bakery products | 6.16% | 8.09% | 10.27% |
| Remaining foodstuff | 0.16% | 0.37% | 0.56% |

Source: own calculation according to Kranert et al. 2012.

The loss rates indicated are added to food purchases of private households (cf. Table 1) as quantity loss rates. The authors use average loss rates for the basic scenario.

At wholesale level, there are no loss rates available differentiated according to product groups. Kranert et al. only indicate the total quantity of food losses for this stage of the value chain. The procedure is as follows: The total quantity of food losses is 551,000 t per year on average. Wholesale trade accounts for 11% of this figure.[39] This is why the authors assume for the purposes of the study that the distribution of losses across individual product groups in the wholesale trade is identical to retailing, but that losses account for only 11% of loss rates in retailing. The following loss rates result for the wholesale trade:

Table 6: Loss rates in the food wholesale trade

| Product groups | losses in % of turnover (total food retail) | | |
|---|---|---|---|
| | Minimum | Average | Maximum |
| Fruits and vegetables | 0.29% | 0.44% | 0.61% |
| Meat/sausage/fish/poultry | 0.06% | 0.18% | 0.29% |
| Milk and dairy products | 0.07% | 0.13% | 0.29% |

[38] Kranert et al. 2012.

[39] Kranert et al. 2012.

| Product groups | losses in % of turnover (total food retail) | | |
|---|---|---|---|
| Bread and bakery products | 0.68% | 0.90% | 1.14% |
| Remaining foodstuff | 0.02% | 0.04% | 0.06% |

Source: own calculation, according to Kranert et al. 2012.

Foodstuffs from Table 1 were allocated to product groups for wholesale and retail trade in the following manner:

Table 7: Allocation of foodstuffs to product groups in terms of loss rates in food retailing

| Product groups | foods |
|---|---|
| Fruits and vegetables | citrus, apples, banana, berries and grapes<br>tomatoes, salad, fresh vegetables and potatoes |
| Meat/sausage/fish/poultry | Beef and veal, pork, poultry, meat products, fish and fish products |
| Milk and dairy products | milk, yoghurt, cream cheese, cheese, cream, butter |
| Bread and bakery products | Bread and bakery products |
| Remaining foodstuff | All remaining foodstuff |

Source: own research.

The respective average loss rates were used in the context of this study.

#### 3.2.3.4 Food losses in food processing

Loss rates quoted in the study by Gustavsson et al. (2011) were used as a reference for the stage of food processing, since no specific data for Germany were available at the time of our research, the FAO study being the only recent study to indicate percentage quantity losses per product group. Kranert et al. (2012) also refer to international studies in the extrapolation of food losses at the processing stage, and use the median from various studies which corresponds to the value given by Monier et al. (2010). The loss rates taken as a basis in this context are presented in table 8.

Table 8: Loss rates in food processing

| Product groups | Loss rate |
|---|---|
| Cereals | 10.5% |
| Roots and tubers | 15.0% |
| Oilseeds and pulses | 5.0% |
| Fruits and vegetables | 2.0% |
| Meat | 5.0% |
| Fish and seafood | 6.0% |
| Milk | 1.2% |

Source: Gustavsson et al. 2011.

#### 3.2.3.5 Loss rates in agricultural production

At the level of agriculture, the focus of research is on losses in post-harvest treatment and storage as well as in agricultural production. Underlying data for the post-harvest treatment and storage of wheat, potatoes and apples grown in Germany are taken from the study by Peter et al. (2013), whereas data from the study by Gustavsson et al. are used for the other foodstuffs and provenances. Calculations are based on the following loss rates in post-harvest treatment and storage:

Table 9: Loss rates in post-harvest treatment and storage

| Food | DE | Europe | North America / Oceania | Asia (industrialized)[40] | Sub-sahara Africa | North Africa, West & Central Asia | South & South-eastern Asia[41] | Latin America[42] |
|---|---|---|---|---|---|---|---|---|
| Wheat | 4.9% | 4.0% | 2.0% | 10.0% | 8.0% | 8.0% | 7.0% | 4.0% |
| Other cereals | 4.0% | 4.0% | 2.0% | 10.0% | 8.0% | 8.0% | 7.0% | 4.0% |
| Potatoes | 5.6% | 9.0% | 10.0% | 7.0% | 18.0% | 10.0% | 19.0% | 14.0% |
| Other roots and tubers | 9.0% | 9.0% | 10.0% | 7.0% | 18.0% | 10.0% | 19.0% | 14.0% |
| Oilseeds and pulses | 1.0% | 1.0% | 0.0% | 3.0% | 8.0% | 6.0% | 12.0% | 3.0% |
| Apples | 11.0% | 5.0% | 4.0% | 8.0% | 9.0% | 10.0% | 9.0% | 10.0% |
| Other fruits and vegetables | 5.0% | 5.0% | 4.0% | 8.0% | 9.0% | 10.0% | 9.0% | 10.0% |
| Meat | 0.7% | 0.7% | 1.0% | 0.6% | 0.7% | 0.2% | 0.3% | 1.1% |
| Fish and Seafood | 0.5% | 0.5% | 0.5% | 2.0% | 6.0% | 5.0% | 6.0% | 5.0% |
| Milk | 0.5% | 0.5% | 0.5% | 1.0% | 11.0% | 6.0% | 6.0% | 6.0% |

Source: Peter et al. 2013; Gustavsson et al. 2011.
Note: Loss rates refer to material flows entering post-harvest treatment and storage.

Calculations are based on the following loss rates in agricultural production:

Table 10: Loss rates in agricultural production

| Food | Europe | North America / Oceania | Asia (industrialized) | Sub-sahara Africa | North Africa, West- & Central Asia | South & South-eastern Asia | Latin America |
|---|---|---|---|---|---|---|---|
| Cereals | 2.0% | 2.0% | 2.0% | 6.0% | 6.0% | 6.0% | 6.0% |

[40] Japan, China and South Corea.

[41] Afghanistan, Bangladesh, Bhutan, India, Indonesia, Iran, Cambodia, Laos, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam.

[42] Argentina, Belize, Bolivia, Brasil, Chile, Costa Rica, Cuba, Dominican Rep., Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Surinam, Uruguay, Venezuela.

| Food | Europe | North America / Oceania | Asia (industrialized) | Sub-sahara Africa | North Africa, West- & Central Asia | South & South-eastern Asia | Latin America |
|---|---|---|---|---|---|---|---|
| Roots and tubers | 20.0% | 20.0% | 20.0% | 14.0% | 6.0% | 6.0% | 14.0% |
| Oilseeds and pulses | 10.0% | 12.0% | 6.0% | 12.0% | 15.0% | 7.0% | 6.0% |
| Fruits and vegetables | 20.0% | 20.0% | 10.0% | 10.0% | 17.0% | 15.0% | 20.0% |
| Meat | 3.1% | 3.5% | 2.9% | 15.0% | 6.6% | 5.1% | 5.3% |
| Fish and Seafood | 9.4% | 12.0% | 15.0% | 5.7% | 6.6% | 8.2% | 5.7% |
| Milk | 3.5% | 3.5% | 3.5% | 6.0% | 3.5% | 3.5% | 3.5% |

Source: Gustavsson et al. 2011.
Note: Loss rates refer to material flows resulting from agricultural production.

The product groups selected for the purposes of the study require allocation to the products of the food shopping basket (see above). At the levels of food processing, post-harvest treatment and agricultural production, foodstuffs of the shopping basket are therefore allocated to the product groups listed in the study in the following manner:

Table 11: Allocation of foodstuffs to product groups

| Food | Product groups |
|---|---|
| Cereals | Rice, Bread and bakery products, pasta |
| Roots and tubers | Potatoes |
| Oilseeds and pulses | Fats and oils |
| Fruits and vegetables | citrus, banana, apples, grapes, dried fruits and nuts, seeds, preserved and frozen fruits<br>tomatoes, salad, fresh vegetables, dreid, frozen and preserved vegetables |
| Meat | Beef and veal, pork, poultry, meat products |
| Fish and Seafood | Fish and fish produts |
| Milk | Milk, yoghurt/cream cheese, cheese, cream, butter |

Source: own research.

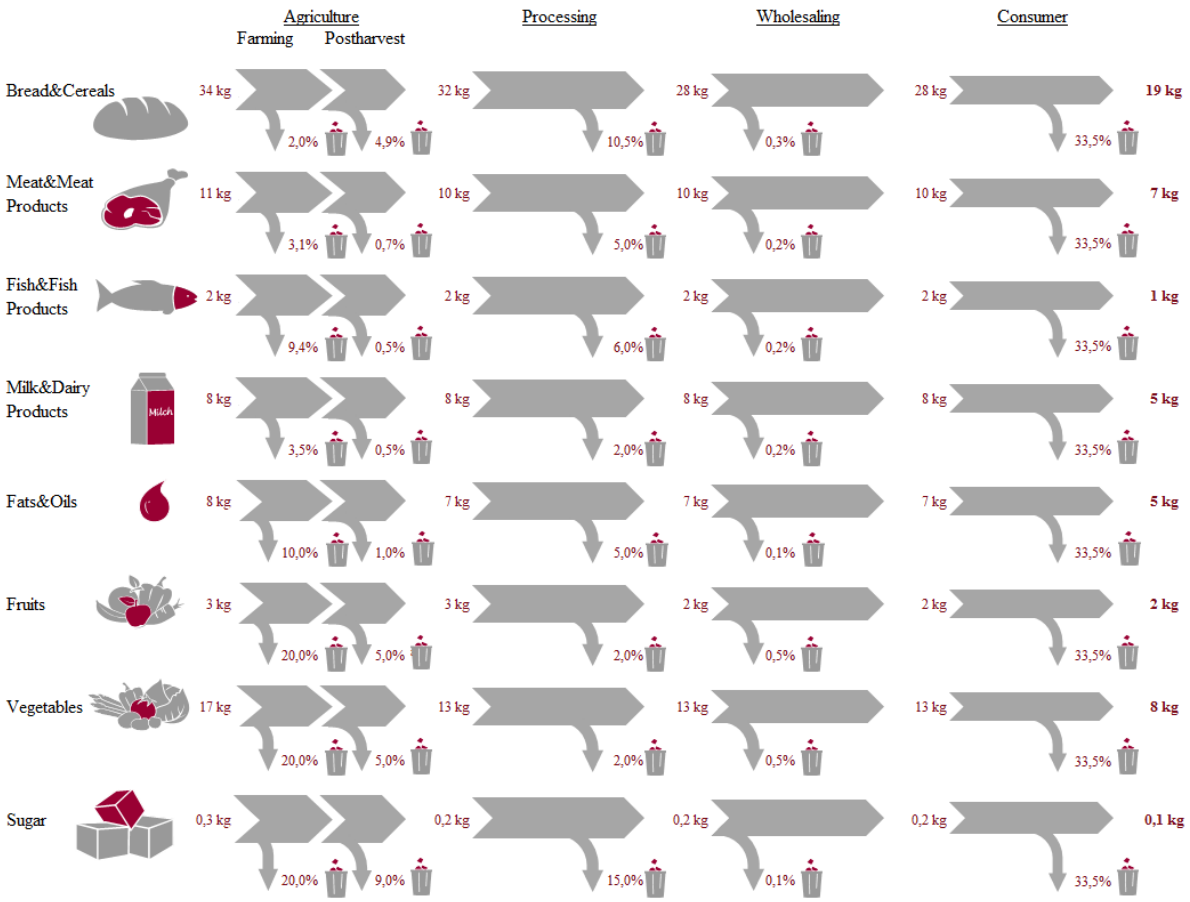
The following two figures summarize the volume flows for the two consumption places, i.e. IHC (see Figure 3) and OHC (see Figure 4). The figures show the absolute product volumes required to provide the respective shopping basket (IHC or OHC) for the listed product groups from left to right along the product life cycle. Percentages indicate loss rates accruing at individual steps in the life cycle respectively, and do not refer to the total volume of agricultural production.

Legend: The annual per capita consumption of bread and cereal products is 93 kg, which requires 125 kg of grain to be grown and provided at the level of agriculture. Since 2% of grain are lost in cultivation and another 4.9% in post-harvest treatment, only 117 kg arrive at the next stage in the life cycle (processing). Of this quantity, another 10.5% are lost, and so on.

Figure 3: Volume flows of product groups under consideration in IHC


Source: own research.

Figure 4: Volume flows of product groups under consideration in OHC




Source: own research.

### 3.2.3.6 Consideration of imports

Not all foodstuffs consumed in Germany originate from domestic production, and not all foodstuffs produced in Germany are consumed within the country. An estimation of the environmental impact of food losses as a result of food demand in Germany therefore requires to explore the provenance of food consumed in Germany.

Unfortunately, production and trade statistics along the product life cycle are not itemized sufficiently for an exact quantity structure of food losses. At the level of food processing in particular, there is no detailed breakdown according to the source of raw materials, i.e. whether from domestic agricultural production or imported.

The following procedure is used in the estimation of material flows to compensate for this data gap: the authors assumed that data on import countries provided by statistics of the Federal Office for Agriculture and Food[43] (see in addition sources quoted in Table 13) correspond to those of the producer country for the respective foodstuff. The imported quantity plus domestic production as quoted in the Statistical Yearbook (BMELV 2012e) add up to the total quantity of food available for processing in Germany, which is used to some part within the country and to some part exported.

[43] BMELV 2012e.

The basic assumption in this procedure is that all imported foodstuffs are consumed in Germany. However, quantities of food are imported to be processed in Germany and then re-exported. No statistics are available which would permit to determine which of the imported raw materials are processed in Germany and subsequently re-exported. This is why the study does not address this aspect.

Since data on imports and exports itemized according to various actors along product life cycles are not available and can therefore not be considered (see above), the analysis is based on the assumption that listed imports occur at the level of food processing exclusively.

As a result, all processing stages are recorded in the balance sheet as if they occurred in Germany exclusively, which does not reflect reality. But it must be noted that only few environment-related data on food processing are available, and those available mainly refer to Europe / Germany, so that a differentiation at this level would hardly be feasible.

The following two tables (Table 12 and Table 13) illustrate the shares of domestic production and imports as well as the shares of the major importing countries in import volumes for the respective foodstuff.

The largest importing countries are considered respectively which taken together account for at least three quarters of imports of the respective product. The respective shares of the main importers in import volumes of the product are then extrapolated to 100%.

Table 12: Domestic production 2012[44] and import of foodstuffs in Germany

| Food | Domestic product [share in %] | Import [reference year] | Import [share in %] |
|---|---|---|---|
| Rice (peeled and unpeeled) | 0% | 2012 | 100% |
| Cereals | 81%* | 2011 | 19% |
| of it wheat | 78% * | 2011 | 22% |
| Beef | 75% | 2012 | 25% |
| Pork | 74% | 2012 | 26% |
| Poultry | 77% | 2012 | 23% |
| Fish (fresh and frozen) | 11% | 2012 | 89% |
| Fresh milk and milk powder | 91% | 2012 | 9% |
| Butter | 78% | 2012 | 22% |
| Cheese | 62% | 2012 | 38% |
| Cream | 74% | 2012 | 26% |
| Eggs | 67%** | 2011 | 33% |
| Oils and fats | 63% | 2011 | 37% |
| Fresh fruits | 39% | 2012 | 61% |
| of it apples | 59% | 2012 | 41% |
| of it oranges | 0% | 2012 | 100% |
| of it banana | 0% | 2012 | 100% |

[44] BMELV 2012e.

| Food | Domestic product [share in %] | Import [reference year] | Import [share in %] |
|---|---|---|---|
| Tomatoes | 10% | 2012 | 90% |
| Potatoes | 95% | 2012 | 5% |
| New potatoes | 82% *** | 2012 | 18% |
| Fresh vegetables | 56% | 2012 | 44% |
| Sugar | 88% | 2011 | 12% |

Explanations: * different reference year: 2010/11
** different source: http://www.bmelv.de/SharedDocs/Pressemitteilungen/2013/096-Eier-Fact-sheet.html
*** different reference year: 2000

Table 13: Main importing countries of food and their import shares

| Food | Top 1 Country | Share | Top 2 Country | Share | Top 3 Country | Share | Top 4 Country | Share | Top 5 Country | Share | Top 6 Country | Share | Top 7 Country | Share | Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rice | IT | 19% | ES | 17% | IN | 14% | BE | 12% | AR | 8% | UY | 10% | | | A |
| Cereals | FR | 23% | CZ | 17% | PL | 13% | NL | 10% | DK | 6% | HU | 5% | UK | 4% | B |
| of it wheat | CZ | 24% | FR | 20% | PL | 14% | NL | 10% | UK | 5% | DK | 5% | | | B |
| Beef | NL | 25% | AT | 11% | FR | 11% | PL | 10% | DK | 9% | AR | 7% | BE | 6% | C |
| Pork | NL | 32% | DK | 24% | BE | 22% | | | | | | | | | C |
| Poultry | NL | 36% | PL | 17% | BE | 7% | AT | 7% | UK | 7% | FR | 6% | | | C |
| Fish | PL | 15% | NO | 12% | CN | 12% | NL | 9% | DK | 8% | USA | 6% | VN | 4% | D |
| Fresh milk and milk powder | AT | 19% | CZ | 17% | BE | 12% | NL | 11% | PL | 10% | IT | 8% | | | E |
| Butter | IE | 40% | NL | 19% | BE | 11% | | | | | | | | | E |
| Cheese | NL | 35% | FR | 19% | DK | 12% | AT | 8% | IT | 5% | | | | | E |
| Cream | NL | 27% | PL | 26% | LT | 15% | BE | 11% | | | | | | | E |
| Eggs | NL | 72% | PL | 14% | | | | | | | | | | | F |
| Fats and oils | NL | 38% | ID | 17% | PG | 6% | MY | 6% | FR | 5% | IT | 4% | PL | 3% | G |
| Fresh fruits | IT | 32% | ES | 26% | NL | 6% | FR | 6% | PL | 3% | CZ | 3% | | | H |
| of it apples | IT | 46% | NL | 16% | FR | 12% | AT | 7% | | | | | | | H |
| of it oranges | ES | 79% | | | | | | | | | | | | | H |
| of it banana | EC | 43% | CO | 25% | | | | | | | | | | | H |
| Tomatoes | NL | 52% | ES | 24% | | | | | | | | | | | H |
| Potatoes | NL | 66% | FR | 13% | | | | | | | | | | | H |

| Food | Top 1 Country | Share | Top 2 Country | Share | Top 3 Country | Share | Top 4 Country | Share | Top 5 Country | Share | Top 6 Country | Share | Top 7 Country | Share | Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| New potatoes | EG | 41% | IL | 16% | ES | 11% | FR | 9% | | | | | | | H |
| Fresh vegetables | NL | 38% | ES | 29% | IT | 10% | MA | 2% | IL | 2% | TR | 1% | | | H |
| Sugar | FR | 42% | PL | 12% | NL | 9% | CZ | 5% | UK | 5% | SZ | 4% | | | I |

Sources:
A: Die deutschen Reismühlen, “Zahlen und Fakten” Online: http://www.reismuehlen.de/index.php?id=12, most recently reviewed 06/01/2013
B: BMELV 2012e, Table 398
C: BMELV 2012b
D: Fisch-Informationszentrum (FIZ) e.V.: Daten und Fakten 2012.
E: BMELV 2012c
F: BMELV 2012e: Table 405
G: BMELV 2012e: Table 401
H: BMELV 2012a
I: BMELV 2012e: Table 403

### 3.2.4 Environmental data

The quality of generic data must meet the following requirements: data must correspond in the best possible manner to the year under review, the place of production (geographical scope) as well as to the state of technology (technological scope). In addition, the data used should be mutually consistent and as valid as possible.

Against this background, required consumption data (consumption of energy, pesticides and fertilizer; land use) and also yield data are taken from the database GEMIS 4.81. It provides the required data on most of the products needed for the analysis in terms of different geographical coverage areas, with the exception of data on water consumption. These are taken from the study by Mekkonen; Hoekstra (2010) which contains data on individual crops and countries, whereas GEMIS largely disregards agricultural water use.

The GEMIS database only depicts consumption data via selected resource consumptions and emissions, and the resulting impact assessment is of limited value at best. The authors therefore support consumption data by generic data sets (e.g. on power generation, production of fertilizers and pesticides) from the database Ecoinvent 3.01; only few data sets not provided by Ecoinvent were complemented by sets from other databases.

The origin of data sets used is shown in a separate data documentation, together with the origin of data sets from GEMIS for data on consumption and yields. The majority of yield data is extracted from the Common Agricultural Policy Regionalized Impact Analysis (CAPRI) Model[45].

### 3.2.5 Modelling

The software Umberto NXT LCA[46] was used for the modelling and calculation of environmental impact.

This software permits to depict the life cycles of foodstuffs contained in the shopping basket in a systematic manner and to calculate the environmental impact resulting from their production.

Modelling reflects four different life cycle stages:

1. **agricultural production** including transport to food processing
2. **food processing** including food transports from processing to wholesale trade
3. **wholesale and retail trade** including food transports between the two sectors
4. **consumption** of food in German households (IHC) or in out-of-home consumption including resulting transports/shopping trips

### 3.2.6 Simplifications

A number of simplifications must be made in the modelling procedure, specifically in view of available or in some instances missing quantity flow and/or environmental data:

- It is assumed for the purposes of the study that all imports occur at the level of food processing and therefore all foodstuffs consumed and processed in Germany such as sugar, bread or cheese are processed in Germany.
  This simplification is made since no environmental data are available on food processing in coun-

[45] http://www.capri-model.org/.

[46] www.umberto.de .

tries exporting to Germany on the one hand, and statistics do not break imports down into product, quantity and life cycle stage on the other[47] The modelling procedure would also become more complex[48] and would have to depict food processing, and in part trade as well, for each country exporting to Germany.
Errors that may result therefrom:

- The environmental impact of transports is moved backward along the life cycle, i.e. towards agricultural production, and the impact attributed to agriculture as a result might be too high. This will mainly apply to greenhouse gas and acidifying emissions. The total environmental impact estimated in this way would be too high; example: sugar beets would be transported from France to Germany instead of sugar which weighs less and would therefore cause less transport emissions.
- Environmental impacts in food processing are estimated on the basis of German consumption data (energy consumption and refrigerant losses). These data may deviate upwards or downwards from consumption data in other countries. Moreover, figures for Germany are used as a reference in accounting for energy generation (German electricity mix) in food processing. This, too, may cause differences in resulting environmental impacts, upwards as well as downwards.

- It is assumed that the production of feed ingredients in other countries corresponds to that in Germany. This simplification was necessary specifically in view of current restrictions in the accounting programme. Another reason is that it turned out to be impossible to research import data on feed ingredients for the respective countries in the project context. The composition of the respective feed (e.g. percentages of wheat and soy meal) were modelled on the basis of country-specific data.
  Errors that may result therefrom:

  - Environmental impacts may be too high or too low for all analysed impact indicators and inventory parameters, due to higher or lower productivity in feed production in the respective country. The authors assume that the resulting error cancels out in the feed mix and that the total environmental impact is approximately correct for the respective feed.
  - However, the allocation of water and land use to countries in the case of animal products is not correct. The simplification results in an overestimate of the share of Germany.
  - In poultry meat production, the share of meat from laying hens (boiling fowls) is neglected, which leads to a slight overestimate of the environmental impact from poultry meat.
- Another assumption is that all products from overseas are imported by ship. This simplification is made since only a small percentage of food imports is transported by air. According to Keller (2010), almost 52,000 tons of food were imported by air in 2008, which corresponded to 0.12% of all food consumed in Germany in that year. The error resulting from this simplification is therefore estimated as low. Nevertheless, individual foodstuffs such as fish are associated with somewhat lower environmental impacts as a result.
- Moreover, the model takes all foodstuffs from conventional agricultural production into account but not those from controlled organic cultivation. Today, food production from controlled organic cultivation accounts for 6% of the surface area in Germany (BLE 2012), with varying percentages for individual product groups.

[47] Statistical data would therefore require to convert figures to quantities and allocate them to products, which again would require further assumptions.

[48] The model used for this study had such a high degree of complexity that it had to be divided into several models in order to permit calculation by the chosen software.

This simplification was made mainly because import data on organic products are not available for all foodstuffs, and because environmental data on organic products are either not consistently available in the database used in the study, or no longer up to date. Errors primarily occur at the level of agriculture since processing and distribution are mainly identical and no specific data are available for organic cultivation. The resulting error may, however, be considered as minor since organic products account for only a small share of the food shopping basket and the agricultural production of organic food also has environmental impacts.

- Another assumption was that private households shop for food in supermarkets. Food purchases from market stalls or directly from farms were not included.
- The assumption for OHC was that products are always supplied by wholesalers.

### 3.2.7 Allocations

Many agricultural production systems have more than one end product. Dairy cows, for example, are kept for milk as the primary product, with meat (veal, cow meat) as a by-product.

The resulting environmental impact must therefore be spread across main product and by-products. There are various allocation methods[49]: allocation by mass, by economic parameters, by energy content/calorific value or product-specific methods.

In the context of the study, allocation methods were applied where market data were available. Care was also taken to avoid unnecessary complications in modelling. A mass allocation was chosen to depict food losses along the life cycle.

Allocations were applied for milk and dairy products. At the level of agricultural production, an economic allocation was chosen to distribute environmental burdens across veal, cow meat and milk. The resulting allocation of environmental effects from dairy farming is 82% to milk, 4% to cow meat (calculated according to its share in beef production) and 14% to calves. For environmental burdens from milk processing, an allocation according to milk dry matter was chosen which currently is considered the “fairest” allocation method for milk products.[50]

For soy meal, an allocation by calorific value was chosen which is also applied in the database used (GEMIS 4.81). In the case of all other agricultural production processes, environmental impacts were allocated 100% to the main product, with a resulting overestimate of environmental burdens from agricultural production.

An allocation by energy yield was applied to energy generation from combined heat and power.

## 3.3 Results from the assessment of environmental impact

The following chapters describe results from the assessment of environmental impacts. Subchapters have been structured in such a way that each subchapter may be studied separately and contains all relevant findings. Nevertheless, some duplications cannot be avoided.

Chapter 3.3.1 initially presents results referring to environmental burdens from the entire food consumption (food eaten and losses). The following subchapters focus on one specific actor respectively along the product life cycle. Chapter 3.3.2 illustrates results from an extrapolation of environmental burdens for individual sectors. Chapters 3.3.3 to 3.3.5 go on to depict results from the three case studies.

[49] Allocation describes the distribution of environmental impacts across main and co-products.

[50] Lundie et al. 2007.

Results are presented for all analysed impact categories and in addition for agricultural use of land and water. Nevertheless, most valid and easiest to interpret are those findings that refer to greenhouse effects, fossil resource consumption, agricultural land use and – to some extent – water consumption as well. These are therefore mainly quoted to support the authors' reasoning. As to water consumption it should be noted that this is a life cycle inventory parameter, i.e. the figure quoted gives the quantity, the environmental impact of which may vary according to region. One litre water consumed around Almeria (Spain) has a different ecological significance compared to one litre consumed in the province of North Holland. An impact assessment of consumption can only be effective if regional origins of food products are known. A breakdown into regions was not feasible in the context of this study. The authors therefore abstained from applying, e.g., the Water Scarcity Method[51] to assess the effects of water use. The same applies to land use: this is another inventory parameter for which no impact assessment is conducted, e.g. in terms of effects on biodiversity[52], since no data are available on the regional provenance of foodstuffs.

### 3.3.1 Environmental effects of food consumption in Germany

The section below presents an initial overview of results, followed by a separate listing according to food eaten and food losses, in-house consumption and out-of-home consumption, and individual life cycle stages.

#### 3.3.1.1 Food consumption in Germany

Based on the entire food consumption in Germany (food eaten and food losses) of 527 kg per capita, a total of 2.7 tons of greenhouse gases are emitted per capita and year. In addition, agricultural production uses 14 cubic meters of water and 2,700 square meters of land per citizen and year. Table 14 depicts per capita results for each analysed indicator, differentiated according to life cycle stages.

Table 14: Environmental impact of food consumption in Germany (food eaten and food losses) per capita and year according to life cycle stages

| Impact category / Parameter | Unit | Agriculture | Processing | Trade | Consumption | SUM |
|---|---|---|---|---|---|---|
| Climate change | kg $CO_2$-eq. | 1,557 | 119 | 58 | 1,016 | 2,750 |
| Fossil depletion | kg Oil-eq. | 269 | 26 | 15 | 450 | 759 |
| Eutrophication (freshwater) | kg P-eq. | 0.16 | 0.08 | 0.05 | 0.73 | 1.03 |
| Eutrophication (marin) | kg N-eq. | 0.92 | 0.16 | 0,01 | 0.21 | 1.31 |
| Metal depletion | kg Fe-eq. | 22 | 1 | 1 | 45 | 70 |
| Stratospheric ozone depletion | g CFC-11-eq. | 0.059 | 0.0057 | 0.003 | 0.125 | 0.193 |
| Particulate matter | kg PM-10-eq. | 2.60 | 0.068 | 0.031 | 0.979 | 3.68 |
| Photochemical Oxidant Formation | kg NMVOC | 10 | 4 | 4 | 45 | 63 |
| Acidification (terrestric) | kg $SO_2$-eq. | 14.8 | 0.2 | 0.1 | 2.6 | 17.6 |

[51] Pfister et al. 2009.

[52] E.g. on the basis of the method suggested by de Baan et al. 2012.

| Impact category / Parameter | Unit | Agricul-ture | Pro-cessing | Trade | Con-sumption | SUM |
|---|---|---|---|---|---|---|
| Agricultural land use | m²*a | 2,673 | - | - | - | 2,673 |
| Agricultural water use | l | 14,016 | - | - | - | 14,016 |

Source: own calculation.

Results show that the stages of agricultural production and consumption account for the main part of the environmental impact of food consumption in Germany, including food losses (food eaten and losses correspond to consumption). For all analysed indicators and parameters, these two stages in the life cycle cause more than 87% of environmental burdens from national food consumption.[53] Processing and trade respectively represent a smaller proportion on environmental burdens.

Greenhouse gas emissions, freshwater and seawater eutrophication, consumption of metallic primary raw materials as well as soil acidification are mainly caused by the consumption of energy along product life cycles and to some part by direct emissions from agriculture (such as methane, nitrous oxide). Fine particulate formation and summer smog (photochemical ozone formation), on the other hand, mainly stem from transport emissions.

The major part of environmental burdens, between 72 and 93% depending on the indicator, is caused by IHC, which also accounts for the largest part of consumed food quantities (87%). OHC accounts for between 7 and 28% of environmental effects, again depending on the indicator, but amounts to only 13% of food quantities consumed (Table 14).

Food losses in IHC and OHC taken together contribute to the environmental impact of German food consumption by 14 – 20%. Food losses due to IHC have a share of 6 – 12% in the environmental effects of food consumption (depending on indicator/parameter), whereas losses in OHC account for 2 – 9% (Table 14).

For both consumption places, food consumption accounts for the largest share of environmental effects in proportion to their quantity shares: IHC and OHC taken together cause between 80 and 86% of environmental effects, depending on the indicator. Depending on indicator/parameter, the share of IHC in the environmental impact of German food consumption is 61 – 80%, and that of OHC is between 5 and 17% (Table 14).

Table 15 shows the annual environmental impact of food consumption extrapolated to Germany.

Table 15: Annual environmental burdens caused by food consumption (food eaten, food losses) in Germany

| Impact category/Parameter | Unit | Consump-tion | Food eaten | Food losses |
|---|---|---|---|---|
| Climate change | Mio. t $CO_2$-eq. | 221.318 | 182.978 | 38.340 |
| Fossil depletion | Mio. t Oil-eq. | 61.104 | 52.351 | 8.753 |
| Eutrophication (freshwater) | t P-eq. | 83,157 | 70,784 | 12,374 |
| Eutrophication (marin) | t N-eq. | 105,107 | 84,590 | 20,517 |
| Metal depletion | Mio. t Fe-eq. | 5.599 | 4.693 | 0.906 |

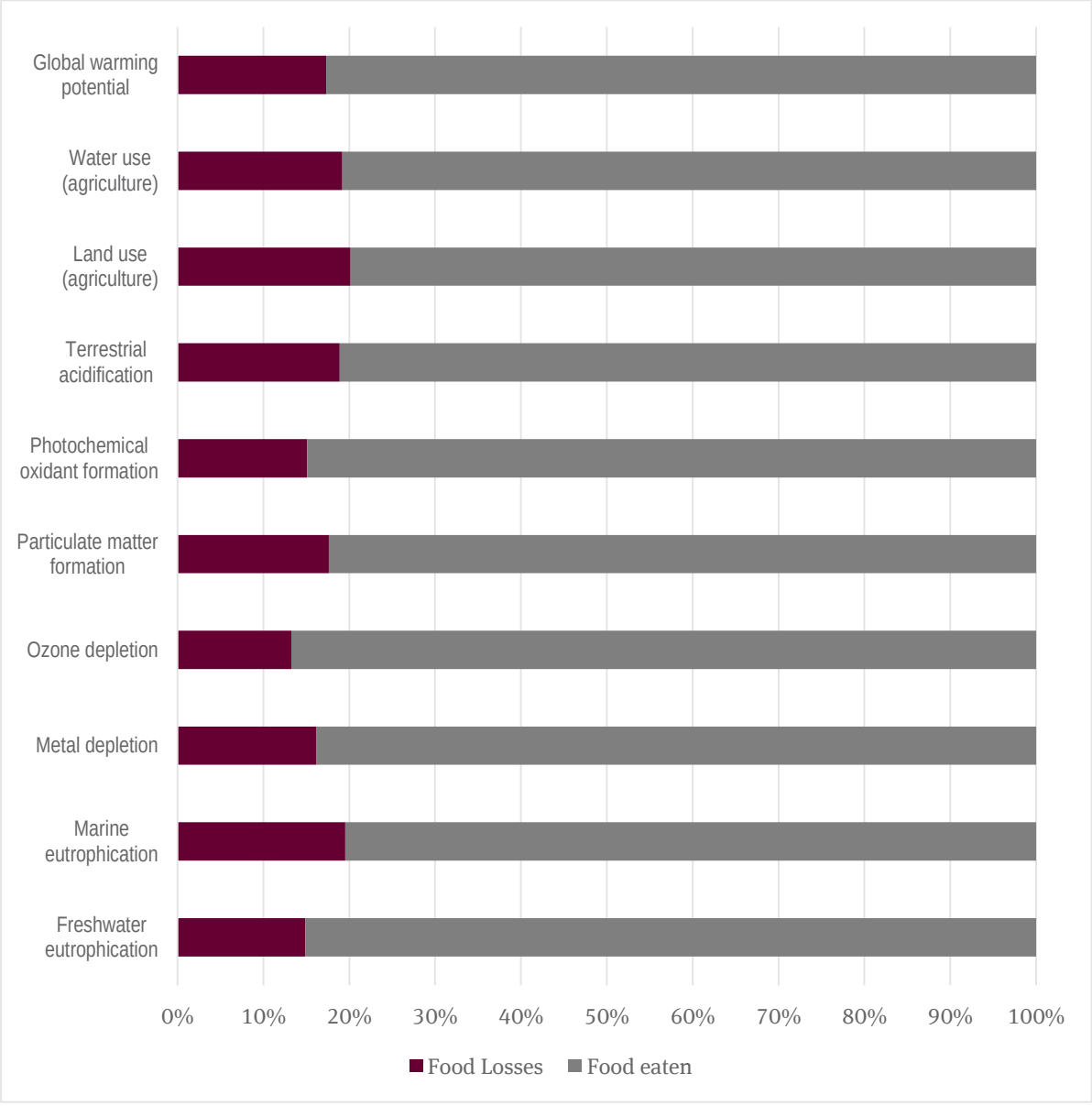
[53] Food consumption = food eaten and food losses.

| Impact category/Parameter | Unit | Consump-tion | Food eaten | Food losses |
|---|---|---|---|---|
| Stratospheric ozone depletion | t CFC-11-eq. | 15.538 | 13.482 | 2.056 |
| Particulate matter | t PM-10-eq. | 296,344 | 244,168 | 52,176 |
| Photochemical Oxidant Formation | Mio. t NMVOC | 5.051 | 4.288 | 0.763 |
| Acidification (terrestric) | t $SO_2$-eq. | 1,418,385 | 1,150,531 | 267,854 |
| Agricultural land use | Mio. ha*a | 21.520 | 17.183 | 4.337 |
| Agricultural water use | Mio. m³ | 1,128.180 | 911.743 | 216.437 |

Source: own calculation.

The next figure illustrates the shares of food consumption and food losses in environmental burdens due to German food consumption according to various environmental categories.

Figure 5: Shares of food consumption and food losses in environmental burdens due to German food consumption



Source: own research.

Results for consumed or discarded products show that foodstuffs of animal origin such as meat and dairy products cause the largest percentage of environmental burdens with the exception of water consumption, although the percentage of vegetable products in consumed and discarded quantities is higher: foodstuffs of animal origin account for 53 – 86% of environmental burdens due to German food consumption, whereas the figure for plant-based foodstuffs is between 14 and 47%. Water usage constitutes the only exception, with 28% attributable to animal products and 72% to vegetable products.

Table 16 shows the environmental impact per kg of average animal and vegetable products from the German food shopping basket (IHC and OHC).

Table 16: Average environmental impact of German food consumption (food eaten and food losses) per kg product

| Impact category/ Parameter | Unit | Animal products | Plant products Produkte | animal and plant products |
|---|---|---|---|---|
| Climate change | kg $CO_2$-eq. | 9.210 | 2.550 | 5.220 |
| Fossil depletion | kg Oil-eq. | 2.100 | 1.000 | 1.440 |
| Eutrophication (freshwater) | g P-eq. | 2.780 | 1.410 | 1.960 |
| Eutrophication (marin) | g N-eq. | 4.920 | 0.847 | 2.480 |
| Metal depletion | kg Fe-eq. | 0.170 | 0.100 | 0.130 |
| Stratospheric ozone depletion | mg CFC-11-eq. | 0.528 | 0.258 | 0.366 |
| Particulate matter | g PM-10-eqquiv. | 13.200 | 2.810 | 6.980 |
| Photochemical Oxidant Formation | kg NMVOC | 0.170 | 0.090 | 0.120 |
| Acidification (terrestric) | kg $SO_2$-eq. | 0.070 | 0.010 | 0.030 |
| Agricultural land use | $m^2$*a | 10.660 | 1.340 | 5.070 |
| Agricultural water use | l | 18.910 | 31.700 | 26.590 |

Source: own calculation.

An eco balance analysis per kg foodstuff reveals that products of animal origin cause a higher potential environmental burden compared to vegetable products for all examined impact categories and parameters with the exception of water. This is particularly obvious in the case of agricultural land use: animal production requires eight times more land per kg compared to plant-based products. Differences are also considerable in terms of the greenhouse potential (four times as high). Water usage is the exception: 1 kg animal product requires only 0.6 of the water used to produce 1 kg vegetable product on average.

The largest proportion of **water** to produce foodstuffs (of animal and vegetable origin) for German consumption is used within Germany (23%), followed by Spain and Pakistan with 18% respectively.[54] An analysis of animal products exclusively shows that most of the water is again used in Germany for feed cultivation, with a considerably higher percentage of 77%.[55] France follows with 11% and Argentina with 9%. In contrast, the production of vegetable foodstuffs requires the largest proportion of water usage in Spain (24%), followed by Pakistan (23%) and the US (9%).

Table 17: National origin of agricultural water use in the production of food

| Country | Unit | Animal products | plant products | Animal and plant products |
|---|---|---|---|---|
| Egypt | l | | 63 | 63 |
| Argentina | l | 282 | | 282 |
| Brasil | l | 44 | | 44 |
| Danmark | l | 6 | 9 | 15 |
| Germany | l | 2,556 | 712 | 3,268 |
| Ecuador | l | | 503 | 503 |
| France | l | 381 | 16 | 397 |
| Great Britain | l | 1 | 712 | 713 |
| India | l | | 300 | 300 |
| Israel | l | | 160 | 160 |
| Italy | l | | 647 | 647 |
| Columbia | l | | 20 | 20 |
| Croatia | l | | 344 | 344 |
| Maroc | l | | 15 | 15 |
| Netherlands | l | 52 | 23 | 75 |
| Austria | l | | 9 | 9 |
| Pakistan | l | | 2,437 | 2,437 |
| Poland | l | 8 | 3 | 10 |
| Spain | l | | 2,521 | 2,521 |
| Swaziland | l | | 12 | 12 |
| Thailand | l | | 884 | 884 |
| Czech Republic | l | 2 | 7 | 10 |
| Turkey | l | | 126 | 126 |
| Hungary | l | 1 | | 1 |
| USA | l | | 925 | 925 |

[54] Assumptions made for rice imports must be considered in interpreting the percentage for Pakistan.

[55] The main reason is the simplification required in modelling feed cultivation, where Germany's share is rather overestimated (cf. chapter 3.2.5).

| Country | Unit | Animal products | plant products | Animal and plant products |
|---|---|---|---|---|
| Vietnam | l | | 293 | 293 |
| **SUM** | **l** | **3,333** | **10,740** | **14,073** |

Source: own calculation.

In terms of **agricultural land use**, the largest areas used to produce food for German consumption are located in Germany (approximately 73%). This applies to animal and vegetable products alike with 73% and 75% respectively. Argentina and Brazil follow with 12% each for the cultivation of soybeans used as animal feed. The Netherlands and the Czech Republic come next with 5% respectively for vegetable production.

Table 18: National origin of agricultural land use for food production

| Country | Unit | Animal products | Plant products | Animal and plant products |
|---|---|---|---|---|
| Egypt | m²*a | | 0.1 | 0.1 |
| Argentina | m²*a | 216.0 | | 216.0 |
| Brasil | m²*a | 216.0 | | 216.0 |
| Danmark | m²*a | 3.1 | 2.1 | 5.2 |
| Germany | m²*a | 1,352.6 | 316.8 | 1,669.4 |
| Ecuador | m²*a | | 3.3 | 3.3 |
| France | m²*a | 15.2 | 11.7 | 26.9 |
| Great Britain | m²*a | 2.4 | 2.0 | 4.4 |
| India | m²*a | | 1.5 | 1.5 |
| Israel | m²*a | | 0.1 | 0.1 |
| Italy | m²*a | | 5.9 | 5.9 |
| Columbia | m²*a | | 1.9 | 1.9 |
| Croatia | m²*a | | 1.8 | 1.8 |
| Maroc | m²*a | | 0.1 | 0.1 |
| Netherlands | m²*a | 9.3 | 21.6 | 30.9 |
| Austria | m²*a | | 0.6 | 0.6 |
| Pakistan | m²*a | | 2.6 | 2.6 |
| Poland | m²*a | 16.9 | 13.0 | 30.0 |
| Spain | m²*a | | 7.6 | 7.6 |
| Swaziland | m²*a | | 0.1 | 0.1 |
| Thailand | m²*a | | 5.4 | 5.4 |
| Czech Republic | m²*a | 25.3 | 20.1 | 45.4 |
| Turkey | m²*a | | 0.1 | 0.1 |
| Hungary | m²*a | 3.6 | | 3.6 |

| Country | Unit | Animal products | Plant products | Animal and plant products |
|---|---|---|---|---|
| USA | m²*a | | 2.5 | 2.5 |
| Vietnam | m²*a | | 4.2 | 4.2 |
| **SUM** | **m²*a** | **1,860.6** | **425.0** | **2,285.6** |

Source: own calculation.

Table 19 shows the environmental impact caused per kg foodstuffs of the German food shopping basket due to food losses. The impact is considerably higher in OHC compared to IHC. This is mainly due to the fact that food losses in OHC are higher than in IHC; but differences in the composition of the shopping basket also influence the extent of environmental burdens. One major reason for the high water consumption, for example, is that far higher quantities of rice are consumed and also thrown away in out-of-home consumption – based on the assumptions made for the study (cf. chapter 3.2.2) – than at home. The figures for land use is also higher in OHC due to higher food losses, and the fact that more meat and rice are consumed outside the home reinforces this tendency. It is, however, important to note that the quantity structure for OHC is subject to far more uncertainties than that for IHC (cf. chapter 3.2.3).

Table 19: Environmental impact due to food losses per kg foodstuffs

| Impact category/Parameter | Unit | IHC | OHC | Total |
|---|---|---|---|---|
| Climate change | kg $CO_2$-eq. | 0.91 | 2.81 | 1.11 |
| Fossil depletion | kg Oil-eq. | 0.22 | 0.56 | 0.25 |
| Eutrophication (freshwater) | g P-eq. | 0.231 | 1.40 | 0.36 |
| Eutrophication (marin) | g N-eq. | 0.479 | 1.55 | 0.596 |
| Metal depletion | kg Fe-eq. | 0.03 | 0.04 | 0.03 |
| Stratospheric ozone depletion | mg CFC-11-eq. | 0.0523 | 0.12 | 0.059 |
| Particulate matter | g PM-10-eq. | 1.31 | 3.21 | 1.52 |
| Photochemical Oxidant Formation | kg NMVOC | 0.01 | 0.09 | 0.02 |
| Acidification (terrestric) | kg $SO_2$-eq. | 0.01 | 0.02 | 0.01 |
| Agricultural land use | m²*a | 0.76 | 5.31 | 1.26 |
| Agricultural water use | l | 4.83 | 18.14 | 6.29 |

Source: own calculation.

#### 3.3.1.2 Food consumption (food eaten)

Food consumed in Germany (i.e. food actually eaten, not including losses) causes 2.3 tons of greenhouse gases per capita and year; approximately 2,135 square metres of agricultural land and more

than 11,33 litres of water are used for its production. Extrapolated to the total consumption in Germany[56], this corresponds to 183.000 kt greenhouse gases, almost 172.000 square kilometres of agricultural land and more than 900 million cubic meters of water.

Food actually eaten accounts for 80 – 87% of the total of environmental effects (depending on indicators) caused by food consumption and losses. The following two tables illustrate the results for each analysed indicator, first differentiating between IHC and OHC and then according to life cycle stages.

Table 20: Environmental burdens caused by food eaten (not including food losses) per capita and year

| Impact category/Parameter | Unit | IHC | OHC | Total |
|---|---|---|---|---|
| Climate change | kg $CO_2$-eq. | 1,990 | 283 | 2,273 |
| Fossil depletion | kg Oil-eq. | 593 | 57 | 650 |
| Eutrophication (freshwater) | kg P-eq. | 0.724 | 0.156 | 0.879 |
| Eutrophication (marin) | kg N-eq. | 0.899 | 0.151 | 1.05 |
| Metal depletion | kg Fe-eq. | 55 | 4 | 58 |
| Stratospheric ozone depletion | g CFC-11-eq. | 0.155 | 0.0124 | 0.167 |
| Particulate matter | kg PM-10-eq. | 2.7 | 0.3 | 3.0 |
| Photochemical Oxidant Formation | kg NMVOC | 42.8 | 10.5 | 53.3 |
| Acidification (terrestric) | kg $SO_2$-eq. | 12.6 | 1.7 | 14.3 |
| Agricultural land use | $m^2$*a | 1,631 | 503 | 2,135 |
| Agricultural water use | l | 9,619 | 1,708 | 11,327 |

Source: own calculation.

Table 21: Environmental burdens caused by food eaten (not including food losses) according to life cycle stages

| Impact category / Parameter | Unit | Agriculture | processing | retailing | Consmption | Total |
|---|---|---|---|---|---|---|
| Climate change | kg $CO_2$-eq | 1,244 | 99 | 48 | 882 | 2,273 |
| Fossil depletion | kg Oil-eq. | 215 | 22 | 12 | 402 | 650 |
| Eutrophication (freshwater) | kg P-eq. | 0.133 | 0.067 | 0.045 | 0.634 | 0.879 |
| Eutrophication (marin) | kg N-eq. | 0.737 | 0.121 | 0.012 | 0.181 | 1.05 |
| Metal depletion | kg Fe-eq. | 18.2 | 0.9 | 0.8 | 38.3 | 58.3 |
| Stratospheric ozone depletion | g CFC-11-eq. | 0.047 | 0.005 | 0.003 | 0.113 | 0.167 |

[56] German population per 31 March 2013: 80,5113 million inhabitants (Federal Statistical Office, https://www.destatis.de/DE/ZahlenFakten/GesellschaftStaat/Bevoelkerung/Bevoelkerungsstand/Tabellen/Zensus_Geschlecht_Staatsangehoerigkeit.html;jsessionid=212A52746774489AB08B26FD8314216B.cae1)

| Impact category / Parameter | Unit | Agriculture | processing | retailing | Consmption | Total |
|---|---|---|---|---|---|---|
| Particulate matter | kg PM-10-eq. | 2.08 | 0.06 | 0.03 | 0.87 | 3.03 |
| Photochemical Oxidant Formation | kg NMVOC | 7.83 | 3.52 | 3.14 | 38.79 | 53.27 |
| Acidification (terrestric) | kg $SO_2$-eq. | 11.77 | 0.17 | 0.07 | 2.29 | 14.29 |
| Agricultural land use | m²*a | 2,135 | - | - | - | 2,135 |
| Agricultural water use | l | 11,327 | - | - | - | 11,327 |

Source: own calculation.

Agricultural production (22% - 82% depending on impact category) and final consumption (16% - 65% depending on impact category) have the largest share in environmental effects. The shares of food processing (1% - 10% depending on impact category) and trade (1% - 5% depending on impact category) are approximately equal.

#### 3.3.1.3 Food losses

Food losses, both avoidable and unavoidable, cause almost half a ton of greenhouse emissions per capita and year, land use of more than 500 square meters and water use of approximately 2.700 litres. Extrapolated to the entire German population[57], this corresponds to 38.340 kilotons of greenhouse emissions per year, agricultural land use of more than 43.000 square kilometres and water use of 216 million cubic meters.

Food losses account for between 13 and 20% of all environmental effects (depending on the indicator) as a consequence of our food consumption. The following two tables depict results for each analysed indicator, first differentiating between IHC and OHC and then according to life cycle stages.

Table 22: Environmental impact due to food losses per capita and year

| Impact category/Parameter | Unit | IHC | OHC | Total |
|---|---|---|---|---|
| Climate change | kg $CO_2$-eq. | 345 | 132 | 476 |
| Fossil depletion | kg oil-eq. | 83 | 26 | 109 |
| Eutrophication (freshwater) | kg P-eq. | 0.088 | 0.066 | 0.154 |
| Eutrophication (marin) | kg N-eq. | 0.182 | 0,073 | 0.255 |
| Metal depletion | kg Fe-eq. | 10 | 2 | 11 |
| Stratospheric ozone depletion | g CFC-11-eq. | 0.02 | 0.006 | 0.026 |
| Particulate matter | kg PM-10-eq. | 0.5 | 0.2 | 0.6 |
| Photochemical Oxidant Formation | kg NMVOC | 5.1 | 4.4 | 9.5 |
| Acidification (terrestric) | kg $SO_2$-eq. | 2.5 | 0.8 | 3.3 |
| Agricultural land use | m²*a | 290 | 249 | 539 |
| Agricultural water use | l | 1,839 | 850 | 2,689 |

[57] German population per 31 March 2013: 80,5113 million inhabitants (Federal Statistical Office, https://www.destatis.de/DE/ZahlenFakten/GesellschaftStaat/Bevoelkerung/Bevoelkerungsstand/Tabellen/Zensus_Geschlecht_Staatsangehoerigkeit.html;jsessionid=212A52746774489AB08B26FD8314216B.cae1=

Source: own calculation.

Table 23: Environmental impact due to food losses per capita and year according to life cycle stages

| Impact category / Parameter | Unit | agricul-ture | pro-cessing | retailing | Con-sump-tion | Total |
|---|---|---|---|---|---|---|
| Climate change | kg $CO_2$-eq. | 313 | 19 | 10 | 134 | 476 |
| Fossil depletion | kg oil-eq. | 54 | 4 | 3 | 48 | 109 |
| Eutrophication (freshwater) | kg P-eq. | 0.030 | 0.014 | 0.009 | 0.1 | 0.154 |
| Eutrophication (marin) | kg N-eq. | 0.188 | 0.037 | 0.025 | 0.028 | 0.255 |
| Metal depletion | kg Fe-eq. | 4.1 | 0.2 | 0.2 | 6.8 | 11.3 |
| Stratospheric ozone depletion | mg CFC-11-eq. | 11.9 | 0.884 | 0.548 | 12.2 | 25.5 |
| Particulate matter | kg PM-10-eq. | 0.52 | 0.01 | 0.01 | 0.11 | 0.65 |
| Photochemical Oxidant Formation | kg NMVOC | 1.83 | 0.67 | 0.66 | 6.32 | 9.47 |
| Acidification (terrestric) | kg $SO_2$-eq. | 3.00 | 0.03 | 0.01 | 0.29 | 3.33 |
| Agricultural land use | $m^2$*a | 539 | | | | 539 |
| Agricultural water use | l | 2,689 | | | | 2,689 |

Source: own calculation.

In view of the volume flow analysis on food losses and the findings on total environmental burdens it is not surprising that the share of agricultural production and end use in environmental burdens is the largest in the category of food losses as well. Here, too, the shares of food processing and trade are approximately equal.

Food losses are certainly not entirely avoidable (cf. chapter 3.1.1). But Kranert et al. estimate that food losses at the level of final consumption might be reduced by about 50%; if this is the case then we might avoid approximately half of the environmental impacts caused by food losses, i.e. the emission of 19.000 kilotons of greenhouse emissions and water use of 108 million cubic meters, and 21.686 square kilometres of agricultural land could be used otherwise.

#### 3.3.1.4 Agriculture

Agricultural production for the German food shopping basket (IHC and OHC, food eaten and food losses) accounts for 1.57 tons of greenhouse emissions per capita. The life cycle stage of agricultural production includes cultivation and losses incurred thereby as well as post-harvest losses. It also accounts for water usage of 14 cubic meters and land use of 0.27 hectares.

Table 24: Environmental impact caused by German food consumption per capita and year in agriculture (cultivation and post harvest treatment)

| Impact category / Paramater | Unit | Total | of it food eaten | of it food losses |
|---|---|---|---|---|
| Climate change | kg $CO_2$-eq. | 1,557 | 1,244 | 313 |

| Impact category / Paramater | Unit | Total | of it food eaten | of it food losses |
|---|---|---|---|---|
| Fossil depletion | kg Oil-eq. | 269 | 215 | 54 |
| Eutrophication (freshwater) | kg P-eq. | 0.164 | 0.134 | 0.030 |
| Eutrophication (marin) | kg N-eq. | 0.925 | 0.737 | 0.188 |
| Metal depletion | kg Fe-eq. | 22 | 18.2 | 4.1 |
| Stratospheric ozone depletion | g CFC-11-eq. | 0.059 | 0.047 | 0.012 |
| Particulate matter | kg PM-10-eq. | 2.60 | 2.08 | 0.52 |
| Photochemical Oxidant Formation | kg NMVOC | 10 | 7.83 | 1.83 |
| Acidification (terrestric) | kg $SO_2$-eq. | 14.77 | 11.77 | 3.00 |
| Agricultural land use | $m^2$*a | 2,673 | 2,135 | 539 |
| Agricultural water use | l | 14,016 | 11,327 | 2,689 |

Source: own calculation.

#### 3.3.1.5 Food processing

Almost 1.7 tons of greenhouse gases are emitted for the production of the German food shopping basket (IHC, OHC, food eaten and food losses) up to and including the level of food processing and also including food losses accrued until then. The table below shows further calculation results.

Table 25: Environmental impact of German food consumption per capita and year, based on agricultural production up to and including the food processing stage

| Impact category / Parameter | Unit | Total | of it food eaten | of it food losses |
|---|---|---|---|---|
| Climate change | kg $CO_2$-eq. | 1,676 | 1,343 | 332 |
| Fossil depletion | kg Oil-eq. | 294 | 236 | 58 |
| Eutrophication (freshwater) | kg P-eq. | 0.245 | 0.201 | 0.044 |
| Eutrophication (marin) | kg N-eq. | 1.08 | 0.86 | 0.22 |
| Metal depletion | kg Fe-eq. | 23 | 19.1 | 4.3 |
| Stratospheric ozone depletion | g CFC-11-eq. | 0.065 | 0.052 | 0.013 |
| Particulate matter | kg PM-10-eq. | 2.67 | 2.14 | 0.53 |
| Photochemical Oxidant Formation | kg NMVOC | 13.5 | 11 | 2.5 |
| Acidification (terrestric) | kg $SO_2$-eq. | 14.9 | 11.9 | 3.0 |
| Agricultural land use | $m^2$*a | 2,673 | 2,134.7 | 538.8 |
| Agricultural water use | l | 14,016 | 11,327.0 | 2,688.9 |

Source: own calculation.

#### 3.3.1.6 Trade

Environmental burdens resulting from production for the German food shopping basket (IHC and OHC, food eaten and food losses) up to and including trade in the product life cycle (wholesale and retail) and including losses incurred up to that point are illustrated in Table 26.

Table 26: Environmental impact of German food consumption per capita and year, based on agricultural production up to and including trade

| Impact category / Parameter | Unit | Total | of it food eaten | of it food losses |
|---|---|---|---|---|
| Climate change | kg $CO_2$-eq. | 1,734 | 1,693 | 41 |
| Fossil depletion | kg Oil-eq. | 310 | 302 | 7 |
| Eutrophication (freshwater) | kg P-eq. | 0.300 | 0.293 | 0.007 |
| Eutrophication (marin) | kg N-eq. | 1.24 | 1.21 | 0.03 |
| Metal depletion | kg Fe-eq. | 24.5 | 23.9 | 0.6 |
| Stratospheric ozone depletion | mg CFC-11-eq. | 67.9 | 66.3 | 1.59 |
| Particulate matter | kg PM-10-eq. | 2.70 | 2.64 | 0.06 |
| Photochemical Oxidant Formation | kg NMVOC | 17.6 | 17.2 | 0.4 |
| Acidification (terrestric) | kg $SO_2$-eq. | 15 | 14.7 | 0.4 |
| Agricultural land use | m²*a | 2,673.5 | 2,611 | 62.5 |
| Agricultural water use | l | 14,016 | 13,688 | 328 |

Source: own calculation.

#### 3.3.1.7 In-house consumption (IHC)

The consumption of food in private households causes 2.3 tons of greenhouse gas emissions and water usage of more than 11 cubic meters per capita and year and accounts for land use of 0.19 hectares which corresponds to half an average football field.

Table 27: Environmental impact of in-house consumption per capita and year

| Impact category/Parameter | Unit | Consumption | of it food eaten | of it food losses |
|---|---|---|---|---|
| Climate change | kg $CO_2$-eq. | 2.334,60 | 1.989,80 | 344,80 |
| Fossil depletion | kg Oil-eq. | 675.70 | 593.00 | 82.70 |
| Eutrophication (freshwater) | kg P-eq. | 0.81 | 0.72 | 0.09 |
| Eutrophication (marin) | kg N-eq. | 1.08 | 0.90 | 0.18 |
| Metal depletion | kg Fe-eq. | 64.30 | 54.70 | 9.60 |
| Stratospheric ozone depletion | g CFC-11-eq. | 0.18 | 0.16 | 0.02 |
| Particulate matter | kg PM-10-eq. | 3.20 | 2.70 | 0.50 |
| Photochemical Oxidant Formation | kg NMVOC | 48.00 | 43.00 | 5.00 |
| Acidification (terrestric) | kg $SO_2$-eq. | 15.10 | 12.60 | 2.50 |
| Agricultural land use | m²*a | 1,921.30 | 1,631.40 | 289.90 |

| Impact category/Parameter | Unit | Consump-tion | of it food eaten | of it food losses |
|---|---|---|---|---|
| Agricultural water use | l | 11,457.90 | 9,619.20 | 1,838.80 |

Source: own calculation.

#### 3.3.1.8 Out-of-home consumption (OHC)

Out-of-home consumption of food per capita and year causes greenhouse gas emissions of 415 kg and water usage of approximately 2.5 cubic meters. About 750 square meters of land are used to produce the foodstuffs. Compared to IHC, OHC accounts for less than one fifth of greenhouse emissions although the food quantities consumed in OHC amount to less than one sixth. This means that the environmental effects per kg food consumed are notably higher for out-of-home consumption.

Table 28: Environmental impact of out-of-home consumption per capita and year

| Impact category/Parameter | Unit | Consump-tion | of it food eaten | of it food losses |
|---|---|---|---|---|
| Climate change | kg $CO_2$-eq. | 415.00 | 283.40 | 131.50 |
| Fossil depletion | kg Oil-eq. | 83.40 | 57.30 | 26.10 |
| Eutrophication (freshwater) | kg P-eq. | 0.22 | 0.16 | 0.07 |
| Eutrophication (marin) | kg N-eq. | 0.22 | 0.15 | 0.07 |
| Metal depletion | kg Fe-eq. | 5.30 | 3.60 | 1.70 |
| Stratospheric ozone depletion | mg CFC-11-eq. | 17.60 | 12.00 | 5.60 |
| Particulate matter | kg PM-10-eq. | 0.47 | 0.32 | 0.15 |
| Photochemical Oxidant Formation | kg NMVOC | 14.40 | 10.00 | 4.40 |
| Acidification (terrestric) | kg $SO_2$-eq. | 2.50 | 1.70 | 0.80 |
| Agricultural land use | $m^2$*a | 752.20 | 503.30 | 248.90 |
| Agricultural water use | l | 2,557.90 | 1,707.80 | 850.10 |

Source: own calculation.

### 3.3.2 Supplementary extrapolation of environmental effects due to food losses in food processing and food trade

In addition to environmental burdens caused by food processing and trade as described in chapters 3.3.1.5 and 3.3.1.6, the following part addresses the environmental impact of all food losses accrued at the level of food processing and trade in Germany determined via extrapolation. In contrast to previous sections this chapter also takes losses of foodstuffs into account which are not consumed in Germany but are exported.

For this purpose the authors extrapolate the average environmental impact per kilogram food in the respective life cycle stage (cf. results shown in previous chapters) to the entire volume of food losses from food processing and trade, based on data from the study by Kranert et al. This method, however, permits no more than an approximate determination of the impact, since the basic assumption here is that the composition of food losses in trade and food processing corresponds to that found for the German food shopping basket (IHC and OHC).

But it is not possible to calculate environmental effects for the stage of agricultural production in this manner. An extrapolation would require the average impact per kilogram of food produced in German agriculture. But our calculation for the life cycle stage of agriculture also includes agricultural goods produced outside Germany. Therefore these data cannot be used in a projection of the environmental impact of German agriculture.

#### 3.3.2.1 Food processing

Food losses in the German food processing sector amount to between 210,000 and 4.58 million tons.[58] Kranert et al. rate a median of 1.85 million tons as the most plausible figure. Taking this median as a basis, food losses accrued in food processing Germany are found to cause almost 5.7 million tons of greenhouse gas emissions per year. The corresponding land use is more than 0.9 million hectares, water use is 48 million cubic meters. The table below illustrates the range of environmental effects from food processing in Germany.

Table 29: Environmental impact of food losses at the level of food processing in Germany

| Impact category / Parameter | Unit | Minimum [210.000 t losses] | Median [1,85 Mio. t losses] | Maximum [4,85 Mio. t losses] |
|---|---|---|---|---|
| Climate change | t $CO_2$-eq. | 651,527 | 5,739,640 | 14,209,486 |
| Fossil depletion | t Oil-eq. | 114,460 | 1,008,334 | 2,496,307 |
| Eutrophication (freshwater) | t P-eq. | 95 | 840 | 2,079 |
| Eutrophication (marin) | t N-eq. | 421 | 3,707 | 9,176 |
| Metal depletion | t Fe-eq. | 9,115 | 80,300 | 198,796 |
| Stratospheric ozone depletion | kg CFC-11-eq. | 25 | 222 | 549 |
| Particulate matter | t PM-10-eq. | 1,039 | 9,152 | 22,657 |
| Photochemical Oxidant Formation | t NMVOC | 5,384 | 47,430 | 117,422 |
| Acidification (terrestric) | t $SO_2$-eq. | 5,818 | 51,251 | 126,882 |
| Agricultural land use | ha/a | 103,955 | 915,794 | 2,267,208 |
| Agricultural water use | $m^3$ | 5,449,867 | 48,010,731 | 118,858,999 |

Source: own calculation based on data on food losses from the study by Kranert et al.

#### 3.3.2.2 Trade

The study by Kranert et al. specifies food losses in German food trade as between 530,000 and 570,000 tons. Taking the median as a basis, food losses at the level of German food trade are found to cause 1.8 million greenhouse gas emissions every year. In addition, 285,000 hectares of land are occupied in the upstream chain (agriculture) , and 15 million cubic meters of water are used. The table below illustrates the range of environmental effects from food trade in Germany based on data on food losses provided by Kranert et al.

[58] Kranert et al.

Table 30: Environmental impact of food losses at the level of food trade in Germany

| Impact category / Parameter | Unit | Minimum [530.000 t losses] | Median [550.000 t losses] | Maximum [570.000 t losses] |
|---|---|---|---|---|
| Climate change | t $CO_2$-eq. | 1,781,958 | 1,849,202 | 1,916,446 |
| Fossil depletion | t oil-eq. | 318,112 | 330,116 | 342,120 |
| Eutrophication (freshwater) | t P-eq. | 308 | 320 | 331 |
| Eutrophication (marin) | t N-eq. | 1,274 | 1,322 | 1,370 |
| Metal depletion | t Fe-eq. | 25,124 | 26,072 | 27,020 |
| Stratospheric ozone depletion | kg CFC-11-eq. | 70 | 72 | 75 |
| Particulate matter | t PM-10-eq. | 2,778 | 2,883 | 2,988 |
| Photochemical Oxidant Formation | t NMVOC | 18,129 | 18,813 | 19,497 |
| Acidification (terrestric) | t $SO_2$-eq. | 15,461 | 16,045 | 16,628 |
| Agricultural land use | ha/a | 274,787 | 285,156 | 295,525 |
| Agricultural water use | $m^3$ | 14,405,763 | 14,949,376 | 15,492,990 |

Source: own calculation based on data from Kranert et al. 2012.

Based on international studies, Kranert et al. additionally determined other volumes of food losses at different life cycle stages for Germany. These figures were used for a sensitivity analysis. The differences between minimum and maximum values are extremely high in this context, varying from 460,000 tons of food losses per annum in trade up to 4.79 million tons.[59] The median is 750,000 tons per year and exceeds by more than one third the figures calculated for Germany on the basis of data provided by EHI and underlying this study (cf. chapter 3.2.3). Accordingly, the environmental impacts of trade are about one third higher if we take the figure as a reference that was determined on the basis of international studies. The following table presents these findings.

Table 31: Sensitivity analysis: Environmental impact of food losses at the level of food trade in Germany

| Impact category / Parameter | Unit | Minimum [460.000 t losses] | Median [750.000 t losses] | Maximum [4.790.000 t losses] |
|---|---|---|---|---|
| Climate change | t $CO_2$-eq. | 1,546,605 | 2,521,639 | 16,104,870 |
| Fossil depletion | t Oil-eq. | 276,097 | 450,158 | 2,875,011 |
| Eutrophication (freshwater) | t P-eq. | 267 | 436 | 2,783 |
| Eutrophication (marin) | t N-eq. | 1,106 | 1,803 | 11,514 |
| Metal depletion | t Fe-eq. | 21,806 | 35,553 | 227,066 |
| Stratospheric ozone depletion | kg CFC-11-eq. | 61 | 99 | 631 |

[59] Kranert et al. 2012, p. 179, table 101.

| Impact category / Parameter | Unit | Minimum [460.000 t losses] | Median [750.000 t losses] | Maximum [4.790.000 t losses] |
|---|---|---|---|---|
| Particulate matter | t PM-10-eq. | 2,411 | 3,931 | 25,108 |
| Photochemical Oxidant Formation | t NMVOC | 15,734 | 25,654 | 163,842 |
| Acidification (terrestric) | t $SO_2$-eq. | 13,419 | 21,879 | 139,735 |
| Agricultural land use | ha/a | 2,384,940 | 3,888,490 | 24,834,488 |
| Agricultural water use | m³ | 12,503,115 | 20,385,513 | 130,195,476 |

Source: own calculation based on data provided by Kranert et al. 2012: table 101, p. 179.

### 3.3.3 Case study asparagus consumption

The case study on asparagus consumption draws up a balance sheet of the environmental impact caused by the cultivation, processing and distribution of asparagus, based on specific data from one asparagus grower which were collected for a doctoral project.[60]

The case study depicts the environmental impact of one kilogram of prepared asparagus and, with a view to the accrual of food losses, the following additional aspects:

- environmental effects at the various stages along the entire value chain
- environmental effects of various cultivation forms (open-field cultivation and heated open-field cultivation)
- environmental effects due to seasonal and out-of-season provision of the product and the resulting different routes and means of transport
- environmental effects of avoidable and unavoidable losses

#### 3.3.3.1 Environmental effects of asparagus cultivation

Asparagus consumption involves 1.82 kg of greenhouse gas emissions per kilogram asparagus, agricultural land use of 1.3 square meters and water use of 0.2 litres. Moreover, 2.28 milligrams of active pesticide substance in solid form and 0.0096 ml in liquid form may have been used in the cultivation[61] (see the following table).

Table 32: Environmental impact of asparagus cultivation in Germany and breakdown into life cycle stages (per kilogram asparagus)

| Impact category/ Parameter | Unit | Total | preparation | Cultivation | harvest/ post harvest | distribution | Consumption |
|---|---|---|---|---|---|---|---|
| Climate change | kg $CO_2$-eq. | 1.820 | 5% | 14% | 13% | 12% | 57% |
| Fossil depletion | kg Oil-eq. | 0.590 | 9% | 7% | 17% | 11% | 56% |
| Eutrophication (freshwater) | g P-eq. | 0.6610 | 1% | 4% | 32% | 12% | 50% |

[60] Schäfer 2014.

[61] Landwirtschaftliches Technologiezentrum Augustenberg 2014.

| Impact category/ Parameter | Unit | Total | preparation | Cultivation | harvest/ post harvest | distribution | Consumption |
|---|---|---|---|---|---|---|---|
| Eutrophication (marin) | g N-eq. | 0.641 | 2% | 21% | 32% | 24% | 21% |
| Metal depletion | kg Fe-eq. | 0.130 | 1% | 9% | 2% | 10% | 78% |
| Stratospheric ozone depletion | mg CFC-11-eq. | 0.128 | 1% | 8% | 16% | 15% | 59% |
| Particulate matter | g PM-10-eq. | 2.200 | 6% | 15% | 10% | 16% | 52% |
| Photochemical Oxidant Formation | kg NMVOC | 0.030 | 1% | 2% | 46% | 5% | 46% |
| Acidification (terrestric) | g $SO_2$-eq. | 5.550 | 7% | 22% | 10% | 15% | 46% |
| Agricultural land use | m²*a | 1.300 | - | 100% | - | - | - |
| Agricultural water use | l | 0.200 | - | 100% | - | - | - |
| Pesticides, solid | mg | 2.280 | - | 100% | - | - | - |
| Pesticides, fluid | ml | 0.010 | - | 100% | - | - | - |

Source: own calculation based on data from Schäfer 2014.

Consumption, i.e. the purchase, storage and preparation of asparagus as well as losses incurred thereby, accounts for the largest share of greenhouse gas emissions with 57%. This applies to all impact indicators with the exception of marine eutrophication. Marketing accounts for between 5 and 16%, and agricultural production for between 26 and 55%.

Data on the use of pesticides are based on spraying recommendations for asparagus issued by the Landwirtschaftliches Technologiezentrum Augustenberg[62] in 2014. It is not clear whether spraying was actually performed. Pertinent data were unavailable, however, so that a conservative assumption was made on the basis of these recommendations.

**Material properties of recommended pesticides**

Table 33 lists in alphabetical order those synthetic pesticides and their properties which were recommended in Germany to prevent certain infestations in the cultivation of asparagus in the year under consideration. Experts recommended the application of potash (potassium hydroxide), mineral oil, copper hydroxide, pyrethrins and azadirachtin (Neem), in addition to the listed substances.

The table below presents the active pesticide substance and type (F = fungicide, H = herbicide, I = insecticide) and lists the following substance properties:

- toxicity (risk phrases 23 to 28) (description see table 34)
- carcinogenicity, mutagenicity, reproductive toxicity[63]

[62] Landwirtschaftliches Technologiezentrum Augustenberg 2014.

[63] Classification according to EU Dangerous substances Directive 67/548 (EC 1967-2009)

- carcinogenicity[64]
- mutagenicity[65]
- reproductive toxicity[66]
- endocrine effects: classification according to EU List of Endocrine Disrupting Chemicals[67]
- water toxicity: R50 (description cf. Table 34)

Table 33: Synthetic pesticides recommended for asparagus cultivation in Germany in 2014 and selected properties

| Active substance | Type | Toxicity | can-cero-gen | muta-gen | Reproduction toxicity | endocrin effects | Toxicity for aquatic organism |
|---|---|---|---|---|---|---|---|
| Azoxystrobin | F | R23 | | | | | R50 |
| Boscalid | F | | | | | | |
| Bromoxynil | H | R25, R26 | | | 3 | 2 | R50 |
| Chlorothalonil | F | R26 | 3 | | | | R50 |
| Clethodim | H | | | | | | |
| Clomazon | H | | | | | | |
| α-Cypermethrin | I | R25 | | | | | R50 |
| Cyprodinil | F | | | | | | R50 |
| Difenconazol | F | | | | | | |
| Dimethenamid-P | H | | | | | | |
| Dimethoat | I | | | | | 2 | |
| Epoxiconazol | F | | 3 | | 3 | | |
| Fluazifop-P-butyl | H | | | | 3 | | R50 |
| Flufenacet | H | | | | | | R50 |
| Glufosinate | H | | | | | | |
| Glyphosate | H | | | | | | |
| Iprodion | F | | 3 | | | 2 | R50 |
| λ-Cyhalothrin | I | R25, R26 | | | | 1 | R50 |
| Metiram | F | | | | | 1 | |
| Metribuzin | H | | | | | 1 | R50 |

[64] EU category 1: known to be carcinogenic to man; EU category 2: which should be regarded as if they are carcinogenic to man; EU category 3: which cause concern for man owing to possible carcinogenic properties

[65] EU category 1: known to be mutagenic to man; EU category 2: which should be regarded as if they are mutagenic to man; EU category 3: which cause concern for man owing to possible mutagenic properties

[66] EU category 1: known to be toxic to human reproduction (fertility); EU category 2: which should be regarded as if they are toxic to human reproduction (fertility); EU category 3: which cause concern for man owing to possible toxic effects on reproduction (fertility)

[67] Category 1: at least one study provided evidence of endocrine disruption in an intact organism; Category 2: potential for endocrine disruptive properties. In vitro experiments (in organs or cells) suggest potentially disruptive effects in an intact organism (EU List of Endocrine Disrupting Chemicals, EC 2004, 2007).

| Active substance | Type | Toxicity | can-cero-gen | muta-gen | Reproduction toxicity | endocrin effects | Toxicity for aquatic organism |
|---|---|---|---|---|---|---|---|
| Pendimethalin | H | | | | | | R50 |
| Pyraclostrobin | F | R23 | | | | | |
| Pyridate | H | | | | | | R50 |
| Tebuconazol | F | | | | | | |
| Tepraloxydim | H | | 3 | | 3 | | |
| Thiacloprid | I | | | | | | |

Source: own research.

Table 34: Explanation of EU risk phrases (R phrases)

| R phrases | Comment |
|---|---|
| R23 | Toxic by inhalation |
| R24 | Toxic in contact with skin |
| R25 | Toxic if swallowed |
| R26 | Very toxic by inhalation |
| R27 | Verx toxic in contact with skin |
| R28 | Verx toxic if swallowed |
| R50 | Very toxic for aquatic organism |

Source : own research.

The table illustrates that several pesticides which are very toxic and potentially harmful to humans and the environment are recommended for application in the cultivation of asparagus, such as the fungicide Chlorthalonil which is highly toxic, very toxic to aquatic organisms and is known to cause cancer in humans, or the fungicide Iprodion which is carcinogenic, has endocrine disruptive effects, and acute toxic effects on aquatic organisms.

In proportion to the quantities of avoidable losses incurred at the further life cycle stages of asparagus, i.e. in processing, trade, preparation and actual consumption, these substances are unnecessarily released into the environment.

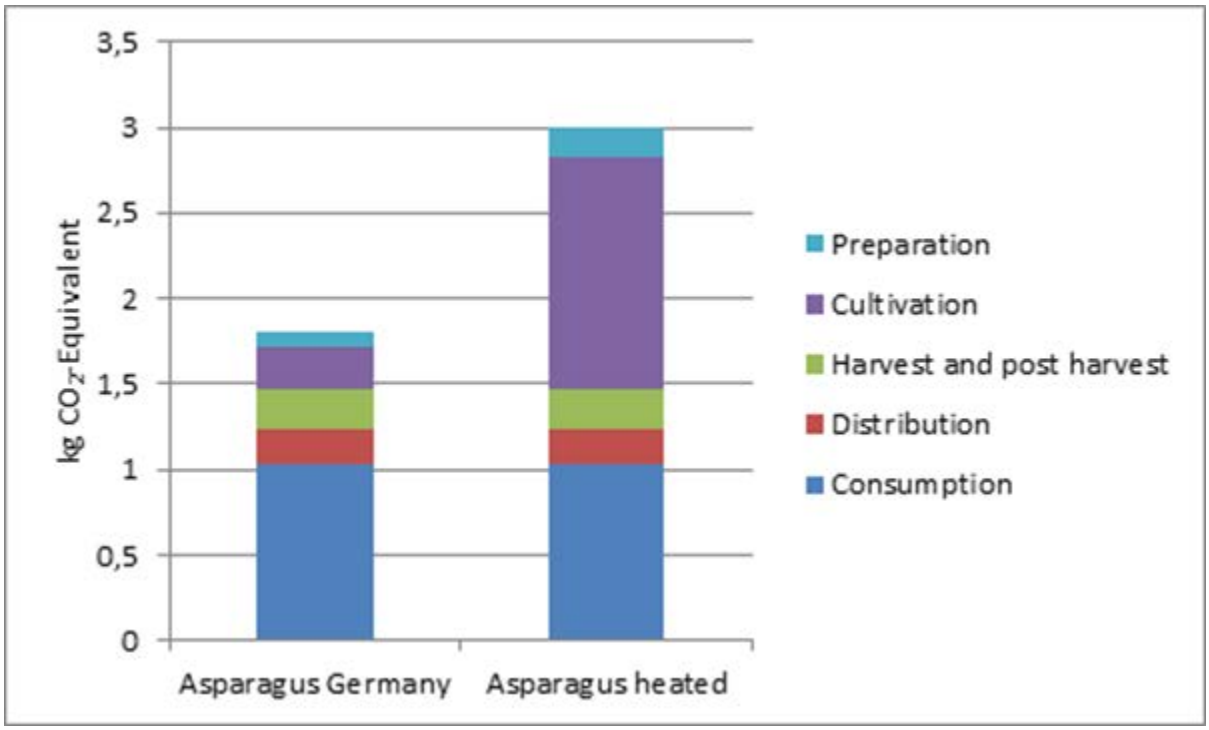
#### 3.3.3.2 Forms of cultivation (open-field cultivation and heated open-field cultivation)

The analysis was based on the assumption that procedures in heated open-field cultivation of asparagus were the same as in unheated cultivation, additional expenses for heating the field being the only difference. This is why the focus of the analysis is on differences in greenhouse emissions exclusively.

In the case under consideration the asparagus field is heated via hot water passed through polyethylene pipes. In the analysed example, waste heat is provided by a near-by carbon black factory. Heat generation is therefore not taken into account as expenses, whereas expenses for laying pipes and for the required pump are included in the calculation.

Greenhouse gas emissions from heated asparagus cultivation exceed those from unheated cultivation by 65%. The difference is caused by differences in field preparation (pipe laying) and energy consumption of the pump during cultivation. All other emissions are the same (Figure 6).

Figure 6: Greenhouse gas emissions per kg asparagus




Source: own research.

#### 3.3.3.3 Seasonal and out-of-season supply of asparagus

In Germany asparagus is available from March to the end of June and again over Christmas. The harvest in Germany is from start/middle of April to late in June and as a rule ends around 24 June (St. John's Day). Heated open-field cultivation permits to bring the start of the harvest forward by about three weeks. Outside this period, however, asparagus is transported to Germany from other growing areas. Asparagus available in March mainly comes from southern Europe, e.g. from Greece, whereas asparagus offered around Christmas comes from remoter regions, primarily from Peru.

The focus of the analysis is therefore on

- regional asparagus in the season from heated and unheated open-field cultivation,
- Greek asparagus transported by truck, and
- asparagus transported from Peru by air or sea.

Table 35 lists transport distances and transport means for the analysed origins of asparagus. Distribution chains cover different numbers of stages. Asparagus from Peru reaches German food retailers via four steps[68], whereas Greek and German asparagus passes through three steps only.[69] Distribution transports have been allocated to the life cycle stage of marketing.

[68] Cultivation – harbour/airport – wholesaler – distribution centre – food retailer

[69] Cultivation – wholesaler – distribution centre – food retailer

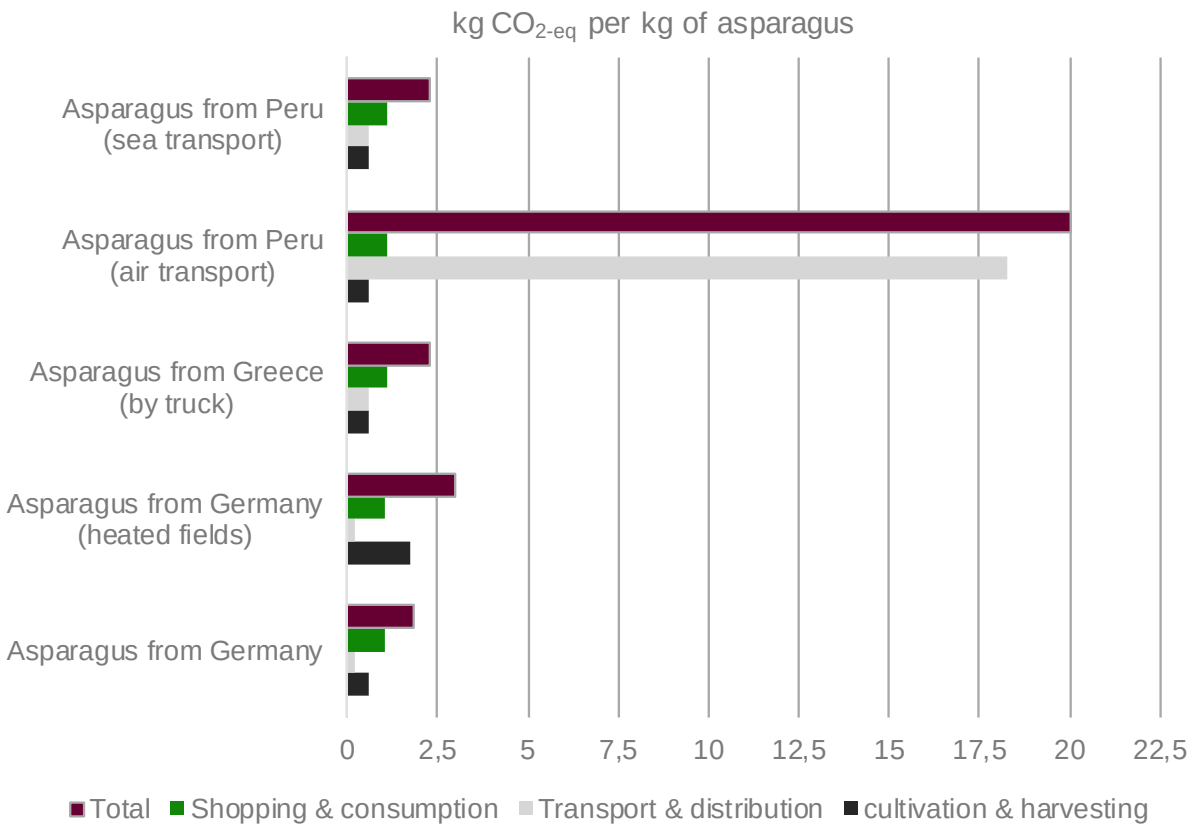
Table 35: Assumptions for different transport routes of asparagus to Germany

| Transport / Country | Start | Destination | Means of transport | km | Source for distance |
|---|---|---|---|---|---|
| **Transport 1** | | | | | |
| Peru (vessel) | La Libertad | Callao | Lorry | 572 | googlemaps |
| Peru (aircraft) | La Libertad | Lima | Lorry | 572 | googlemaps |
| Greece (truck) | Cultivation area | Wholesale (Arta) | Lorry | 20 | Schäfer 2014 |
| Germany (truck) | Cultivation area | Wholesale (Germany) | Lorry | 20 | Schäfer 2014 |
| **Transport 2** | | | | | |
| Peru (vessel) | Callao | Hamburg / Wholesale | Vessel | 11.913 | portdistance.com |
| Peru (aircraft) | Lima | Frankfurt / Wholesale | aircraft | 10.736 | luftlinie.org |
| Greece (truck) | Wholesale (Arta) | Distribution centre | lorry | 2.167 | googlemaps |
| Germany (truck) | Wholesale (Germany) | Distribution centre | lorry | 200 | Schäfer 2014 |
| **Transport 3** | | | | | |
| Peru (vessel) | Wholesale | Distribution centre | Lorry | 200 | Schäfer 2014 |
| Peru (aircraft) | Wholesale | Distribution centre | Lorry | 200 | Schäfer 2014 |
| Greece (truck) | Distribution centre | Food retailer | Lorry | 160 | Schäfer 2014 |
| Germany (truck) | Distribution centre | Food retailer | Lorry | 160 | Schäfer 2014 |
| **Transport 4** | | | | | |
| Peru (vessel) | Distribution centre | Food retailer | Lorry | 160 | Schäfer 2014 |
| Peru (aircraft) | Distribution centre | Food retailer | Lorry | 160 | Schäfer 2014 |

Source: own research.

Findings show that asparagus brought in by air causes notably more greenhouse gas emissions due to high emissions in aviation compared to Greek asparagus and Peruvian asparagus imported by sea. Emissions for asparagus flown in during the life cycle stage of "marketing" (mainly transport emissions) are about 30 times as high as for Greek asparagus imported by road. Asparagus imported from Peru by sea causes comparatively low amounts of greenhouse gas emissions due to the large transport capacities of ocean-going vessels. In the case study under consideration they are even smaller than those for Greek asparagus transported over land. It must be noted that the authors had to assume identical cultivation methods for asparagus in Germany, Peru and Greece since no pertinent data were available. Variations were registered only for transport distances, means of transport and the quantity of avoidable waste. The latter is based on the assumption that long transport routes cause higher quantities of asparagus to perish and dry out compared to shorter routes.

Figure 7: Greenhouse gas emissions for asparagus of various origins




Source: own research.

#### 3.3.3.4 Avoidable and unavoidable food losses

As explained above, the case study on asparagus also examined the differentiation between avoidable and unavoidable food waste, i.e. the question which food losses in the case of asparagus are avoidable, which are unavoidable, and their respective share in losses.

Food losses are not always avoidable. Some cases are clear, such as banana skin, or a bone which may be boiled to obtain marrow for marrow dumplings but in itself is unfit for consumption. Other food losses might be eaten but their consumption is not permitted for reasons of food safety, e.g. so called risk materials[70] in bovine animals. Other examples of food losses cannot be unequivocally defined as avoidable or unavoidable, such as potato peelings. Here the classification as avoidable or unavoidable depends on the type of preparation: potato skins are unavoidable loss in the case of boiled potatoes, but may be consumed in jacket potatoes and in this case count as avoidable.

The average waste from one kilogram of asparagus of normal thickness was determined as 230 grams, and a section weighing between 14 and 81 grams was cut off from the lower end, depending on the freshness of the product.

The following part is based on the assumption that waste in the form of peelings is unavoidable in asparagus. Even if asparagus peelings are boiled to prepare soup they are still disposed of afterwards. But losses from cutting off a section at the lower end can be avoided to some extent. For very fresh

[70] Risk materials are parts of bovine animals which must not be used for consumption, not even for animal feed.

asparagus, e.g. direct from farm sales, this section can be kept very small. Over long transport distances, asparagus tends to dry up from the end so that a larger section needs to be cut off. Our case study shows that up to 67 grams of waste (6.7%) per kilogram of fresh asparagus may be avoided in this manner.

Based on a medium-size section to be cut off, one kilogram of consumed asparagus accounts for 1.82 kg greenhouse gas emissions. In case of small sections to be removed, e.g. with very fresh asparagus, the total of resulting greenhouse emissions is 1.765 kg. For asparagus transported over long routes and therefore no longer fresh we may assume that larger sections need to be cut off, which results in greenhouse emissions of 1.925 kg along the life cycle.

Table 36: Environmental impact per kilogram of prepared asparagus, differing sizes of sections cut off

| Impact category/Parameter | Unit | Section cut off short | Section cut off middle | Section cut off long |
|---|---|---|---|---|
| Climate change | kg $CO_2$-eq. | 1.765 | 1.820 | 1.925 |
| Agricultural land use | m²*a | 1.260 | 1.299 | 1.374 |
| Agricultural water use | l | 0.191 | 0.197 | 0.208 |
| Pesticides, solid | mg | 0.002 | 0.002 | 0.002 |
| Pesticides, fluid | ml | 0.009 | 0.010 | 0.010 |

Source: own calculation.

In view of the difference in loss quantities between fresh and older asparagus, a reduction of the time between harvest and consumption serves to reduce the environmental impact of asparagus consumption (asparagus eaten and losses). If only a smaller section needs to be cut off from the lower end, then 80 grams of greenhouse gas emissions may be saved per portion of 500 grams which corresponds to a car drive of approximately half a kilometre.

### 3.3.4 Case study formats of provision in retailing

This case study explores the potential environmental impact resulting from differing formats of provision in retailing using the example of tomatoes. The focus is on the different amounts of losses in the case of tomatoes offered in loose form vs. in packages of 500 grams.

The basic assumption for both formats is a 1% proportion of spoilage. Another assumption is that in the case of loose tomatoes single spoilt tomatoes are sorted out and thrown away whereas entire packages are thrown away in which single tomatoes are rotten. Since the distribution of rotten tomatoes in packages may vary, the possible range is indicated. Assuming an average weight of 55 grams per tomato, a 500-gram package contains nine to ten tomatoes. The packages are assumed to actually weigh more than 500 grams, i.e. an average plus of 5%, so that the actual filling weight is 525 grams on average.

#### 3.3.4.1 Environmental impact

The calculation of environmental burdens in this case study is performed for ten crates of tomatoes. The weight of an average crate is eight kilograms[71], which means that ten crates contain a total of 80 kg tomatoes. A spoilage rate of 1% means that 800 grams of tomatoes need to be sorted out.

For loose tomatoes the food loss therefore amounts to 800 grams. This corresponds to 14 to 15 tomatoes which must be sorted out from the eight crates and thrown away.

For packaged tomatoes, these 14 to 15 tomatoes are distributed across at least two packages. This means that a minimum of two packages are thrown away, which corresponds to 1.05 kg tomatoes or 1.3%, assuming an actual filling weight of 525 grams. If the 15 rotten tomatoes are distributed across 15 different packages, then a maximum of 15 packages must be sorted out, which corresponds to 7.7875 kg or 9.8%.

Extrapolated to the entire tomato consumption in Germany and assuming a spoilage rate of 1%, 17,284 t of loose tomatoes would be thrown away in retailing per year. If all tomatoes would be offered in packages of 500 grams, a total of between 18,000 and 165,000 tons of tomatoes would be thrown away per year.

For loose tomatoes, 18,906 tons of greenhouse gas emissions would correspond to the tomatoes sorted out (Table 37), whereas a maximum of 171,871 tons of emissions would accrue for packaged tomatoes (Table 38). Assuming that the entire range of tomatoes offered in the retail trade is packaged and the format is then changed into the sale of loose tomatoes exclusively, a maximum of about 150,000 tons of greenhouse gas emissions could be saved under the given assumptions. This corresponds to the average per capita emissions of 12.500 to 15.000 German consumers based on a per capita emission of between 10 and 12 tons of greenhouse gas emissions per year.

Table 37: Environmental impact from tomato losses in trade for 100% of loosely offered tomatoes, extrapolated to the entire tomato consumption in Germany

| Impact category/Parameter | Unit | Agriculture | Trade | Total |
|---|---|---|---|---|
| Climate change | t $CO_2$-eq. | 15,888 | 3,018 | 18,906 |
| Fossil depletion | t Oil-eq. | 12,781 | 784 | 13,565 |
| Eutrophication (freshwater) | t P-eq. | 0.77 | 2.63 | 3.40 |
| Eutrophication (marin) | t N-eq. | 3.33 | 0.69 | 4.02 |
| Metal depletion | t Fe-eq. | 281 | 49 | 330 |
| Stratospheric ozone depletion | t CFC-11-eq. | 0.003 | 0.0002 | 0.003 |
| Particulate matter | t PM-10-eq. | 15.5 | 1.5 | 17.0 |
| Photochemical Oxidant Formation | t NMVOC | 59 | 183 | 242 |
| Acidification (terrestric) | t $SO_2$-eq. | 46 | 4 | 50 |
| Agricultural land use | $km^2$*a | 1.74 | | 1.74 |
| Agricultural water use | $m^3$ | 163,522 | | 163,522 |

Source: own calculation.

[71] Pelka; Kreyenschmidt 2013.

Table 38: Environmental impact from tomato losses in trade for tomatoes offered in packages (500g), extrapolated to the entire tomato consumption in Germany (maximum)

| Impact category/Parameter | Unit | Agriculture | Trade | Total |
|---|---|---|---|---|
| Climate change | t $CO_2$-eq. | 144,439 | 27,432 | 171,871 |
| Fossil depletion | t oil-eq. | 116,193 | 7,128 | 123,321 |
| Eutrophication (freshwater) | t P-eq. | 7 | 24 | 31 |
| Eutrophication (marin) | t N-eq. | 30.26 | 6.25 | 36.51 |
| Metal depletion | t Fe-eq. | 2,558 | 442 | 3,000 |
| Stratospheric ozone depletion | t CFC-11-eq. | 0.02 | 0.00 | 0.02 |
| Particulate matter | t PM-10-eq. | 141 | 14 | 155 |
| Photochemical Oxidant Formation | t NMVOC | 538 | 1,661 | 2,199 |
| Acidification (terrestric) | t $SO_2$-eq. | 414 | 37 | 451 |
| Agricultural land use | $km^2*a$ | 15.85 | - | 15.85 |
| Agricultural water use | $m^3$ | 1,486,565 | - | 1,486,565 |

Source: own calculation.

Assuming that about one third of tomatoes offered today are in packages, this would still amount to up to 50,000 tons of greenhouse emissions from tomato losses which a different format of provision might help to avoid. Environmental burdens due to packaging do not form part of this analysis.

### 3.3.5 Case study OHC

As illustrated in chapter 3.3.1, the share of losses in the environmental effects of out-of-home consumption is more than 30%, so that reduction initiatives appear expedient, despite the comparably small share of OHC in total environmental effects of only nine to 23%.

This case study therefore explores the environmental impact of a general reduction of food waste in out-of-home consumption through better kitchen management, for example by means of varied formats of presentation (meals counter vs. buffet) or better planning.

Another focus is on the potential effects of changes in the composition of food waste if losses can be reduced specifically for environmentally intensive foodstuffs such as meat or dairy products.

#### 3.3.5.1 Environmental impact of a general reduction of losses

The basic assumption is that food losses in out-of-home consumption can be reduced by 20%, with a corresponding 20% reduction of the impact of these losses. A reduction of losses in OHC by 20% would reduce the environmental burdens caused by the entire food consumption in Germany by 6 to 7%. Table 39 presents results for the analysed indicators and parameters.

Table 39: Reduction of per capita impact of OHC resulting from a reduction of food losses by 20%

| Impact category / Parameter | Unit | OHC food eaten | OHC losses | OHC consumption | Relation: OHC losses (-20%) | relation: OHC Consumption (OHC losses -20%) |
|---|---|---|---|---|---|---|
| Climate change | 10 kg $CO_2$-eq. | 28.34 | 13.15 | 41.50 | 10.52 | 38.87 |
| Fossil depletion | 10 kg Oil-eq. | 5.73 | 2.61 | 8.34 | 2.09 | 7.82 |
| Eutrophication (freshwater) | kg P-eq. | 0.16 | 0.07 | 0.22 | 0.05 | 0.21 |
| Eutrophication (marin) | kg N-eq. | 0.15 | 0.07 | 0.22 | 0.06 | 0.21 |
| Metal depletion | kg Fe-eq. | 3.58 | 1.67 | 5.26 | 1.34 | 4.92 |
| Stratospheric ozone depletion | mg CFC-11-eq. | 12.40 | 5.62 | 18.00 | 4.50 | 16.90 |
| Particulate matter | kg PM-10-eq. | 0.32 | 0.15 | 0.47 | 0.12 | 0.44 |
| Photochemical Oxidant Formation | kg NMVOC | 10.50 | 4.39 | 14.89 | 3.51 | 14.01 |
| Acidification (terrestric) | kg $SO_2$-eq. | 1.68 | 0.82 | 2.50 | 0.66 | 2.33 |
| Agricultural land use | 100 m²*a | 5.03 | 2.49 | 7.52 | 1.99 | 7.02 |
| Agricultural water use | 100 l | 17.08 | 8.50 | 25.58 | 6.80 | 23.88 |

Source: own calculation.

Accordingly, a reduction of losses by 50% would reduce environmental burdens by 15 to 17% in total (Table 40).

Table 40: Reduction of per capita impact of OHC from a reduction of food losses by 50%

| Impact category / Parameter | Unit | OHC food eaten | OHC losses | OHC consumption | Relation: OHC losses (-50%) | relation: OHC Consumption (OHC losses -50%) |
|---|---|---|---|---|---|---|
| Climate change | 10 kg $CO_2$-eq. | 28.34 | 13.15 | 41.50 | 6.58 | 34.92 |
| Fossil depletion | 10 kg Oil-eq. | 5.73 | 2.61 | 8.34 | 1.30 | 7.04 |
| Eutrophication (freshwater) | kg P-eq. | 0.16 | 0.07 | 0.22 | 0.03 | 0.19 |
| Eutrophication (marin) | kg N-eq. | 0.15 | 0.07 | 0.22 | 0.04 | 0.19 |
| Metal depletion | kg Fe-eq. | 3.58 | 1.67 | 5.26 | 0.84 | 4.42 |
| Stratospheric ozone depletion | mg CFC-11-eq. | 12.40 | 5.62 | 18.00 | 2.81 | 15.20 |
| Particulate matter | kg PM-10-eq. | 0.32 | 0.15 | 0.47 | 0.08 | 0.39 |

| Impact category / Parameter | Unit | OHC food eaten | OHC losses | OHC consumption | Relation: OHC losses (-50%) | relation: OHC Consumption (OHC losses -50%) |
|---|---|---|---|---|---|---|
| Photochemical Oxidant Formation | kg NMVOC | 10.50 | 4.39 | 14.89 | 2.20 | 12.69 |
| Acidification (terrestric) | kg $SO_2$-eq. | 1.68 | 0.82 | 2.50 | 0.41 | 2.09 |
| Agricultural land use | 100 m²*a | 5.03 | 2.49 | 7.52 | 1.24 | 6.28 |
| Agricultural water use | 100 l | 17.08 | 8.50 | 25.58 | 4.25 | 21.33 |

Source: own calculation.

#### 3.3.5.2 Environmental impact of a changed composition of losses

Here the assumption is that expedient measures will serve to reduce food losses from animal products by 50%. Food losses from plant-based products remain the same. Food losses in animal products have a share of between 39 and 89% in the total environmental impact of food losses in OHC.

Table 41: Per capita impact of OHC from food losses and distribution across animal-based and plant-based foodstuffs

| Impact category / Parameter | Unit | OHC losses | of it of animal origin | of it of plant origin | Share of animal origin |
|---|---|---|---|---|---|
| Climate change | kg $CO_2$-eq. | 132 | 85 | 47 | 65% |
| Fossil depletion | kg oil-eq. | 26 | 14 | 12 | 55% |
| Eutrophication (freshwater) | kg P-eq. | 0.07 | 0.03 | 0.04 | 40% |
| Eutrophication (marin) | kg N-eq. | 0.073 | 0.057 | 0.016 | 78% |
| Metal depletion | kg Fe-eq. | 1.7 | 0.9 | 0.7 | 55% |
| Stratospheric ozone depletion | mg CFC-11-eq. | 5.62 | 3.08 | 2.54 | 55% |
| Particulate matter | kg PM-10-eq. | 0.15 | 0.12 | 0.03 | 80% |
| Photochemical Oxidant Formation | kg NMVOC | 4.4 | 1.7 | 2.7 | 39% |
| Acidification (terrestric) | kg $SO_2$-eq. | 0.8 | 0.7 | 0.1 | 89% |
| Agricultural land use | m²*a | 249 | 217 | 32 | 87% |
| Agricultural water use | l | 850 | 370 | 480 | 43% |

Source: own calculation.

A reduction of animal-based food losses in OHC by 50% would permit to reduce the environmental impact of food losses incurred in OHC by between 19 and 44%, and the impact of OHC in total by between 6 and 15% (Table 42).

Table 42: Reduction of per capita impact of OHC from a reduction of food losses in animal products by 50%

| Impact category / Parameter | Unit | reduction OHC losses | Reduction OHC consumption |
|---|---|---|---|
| Climate change | kg $CO_2$-eq. | 32% | 10% |
| Fossil depletion | kg oil-eq. | 28% | 9% |
| Eutrophication (freshwater) | kg P-eq. | 20% | 6% |
| Eutrophication (marin) | kg N-eq. | 39% | 13% |
| Metal depletion | kg Fe-eq. | 28% | 9% |
| Stratospheric ozone depletion | mg CFC-11-eq. | 27% | 9% |
| Particulate matter | kg PM-10-eq. | 40% | 13% |
| Photochemical Oxidant Formation | kg NMVOC | 19% | 6% |
| Acidification (terrestric) | kg $SO_2$-eq. | 44% | 15% |
| Agricultural land use | $m^2$*a | 44% | 14% |
| Agricultural water use | l | 22% | 7% |

Source: own calculation

## 3.4 Discussion of findings

Greenhouse gas emissions of 2.7 tons per capita and year are caused by German food consumption (food eaten and food losses). This is roughly equivalent to emissions in a flight from Frankfurt to New York and back.[72] The water usage in agricultural production is 14 cubic metres (for comparison: this equals about 70 full bathtubs)[73] and land use is 2.673 square metres for the production of food per German citizen and year (for comparison: ca. one third of a football field)[74]. These results illustrate the high relevance of food consumption (food eaten and food losses) in terms of environmental impact.

Overall, results are comparable in size to those of earlier studies assessing the environmental impact of food consumption in Germany. But there is evidence of some discrepancies.

According to Wiegmann et al. (2005a) greenhouse gas emissions resulting from German food consumption are about 25% lower compared to this study; the authors employed comparable methods but a different database. Wiegmann et al. (2005b) considered data on food waste to only a limited extent since adequate data were sparse. Meier (2014) analysed food consumption in Germany but neglected to take energy consumption for storage and preparation of food in private households into account. Meier (2014) calculated greenhouse gas emissions which were about 9% lower compared to the findings of this study; nevertheless, his findings for greenhouse gas emissions are more or less on the same scale. Differences may therefore be mainly explained by different databases (both studies used GEMIS and not basis data from Ecoinvent) and by different system boundaries. In comparison

[72] www.atmosfair.de

[73] assuming an average of 200 l per tub

[74] A standard football field (FIFA recommendations) has 7.140 square metres.

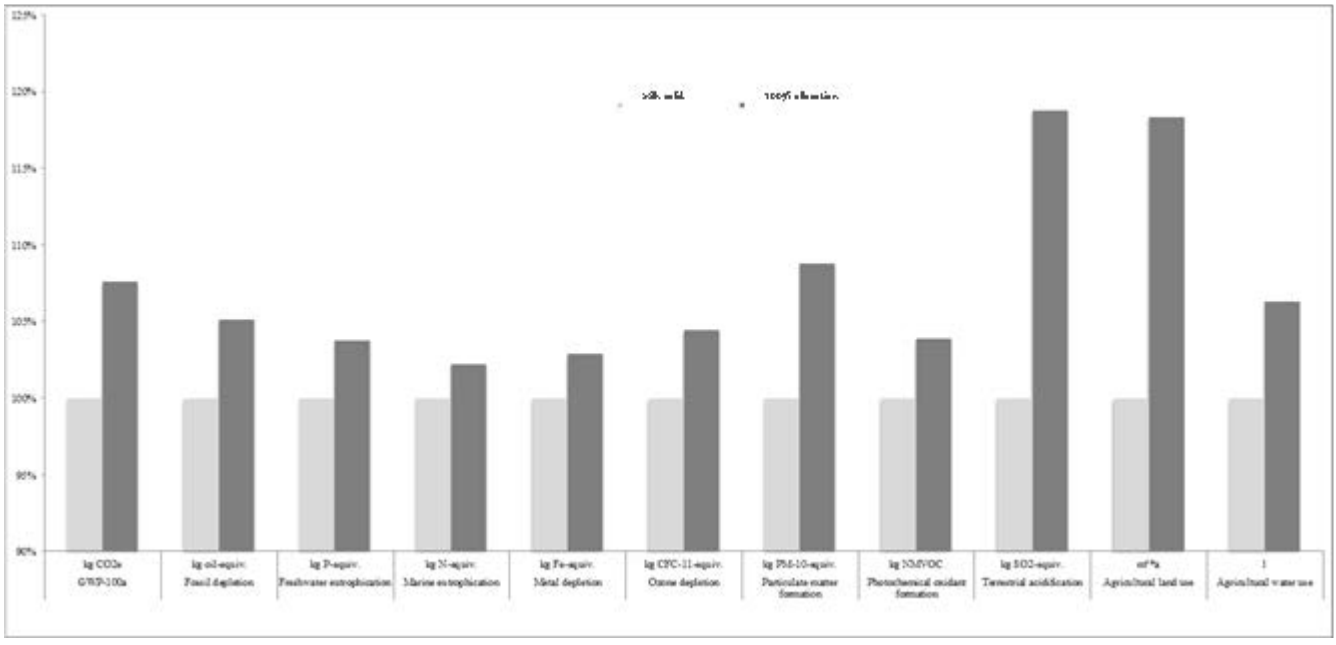
with the Ecoinvent database, greenhouse gas emissions based on GEMIS are generally reported as lower. This applies in particular to data sets on power generation.

Differences are greater in terms of water use for agricultural production. Meier calculated a water usage of 32.5 cubic metres per capita and year, which is more than twice as much as the figure found in our study. The main reason is that Meier assumed nuts to account for about one third of water use in German food consumption, whereas our study subsumed nuts under “other fruit” and did not consider the specific water use in the cultivation of nuts. Another reason is the varying composition of the food shopping basket, specifically in terms of the provenance of foodstuffs which can be decisive for water consumption.

As to land usage, the results from Meier (2014), Wiegmann et al. (2005a) and Kastner et al. (2012) are about 10% lower than those found in our study. Among the main reasons are the different harvesting data underlying these studies. We used data on harvested quantities from GEMIS 4.81 which are primarily based on the so called CAPRI model (Common Agricultural Policy Regionalized Impact Analysis modelling system[75]).

Findings in this study must moreover be discussed in the light of the allocation method employed (cf. chapter 3.2.7). A sensitivity analysis is therefore performed to determine the impact of the allocation method used for dairy farming and milk processing. In this analysis, environmental effects are allocated to the product by 100% in both cases. Findings show that the choice of method has a notable influence on the result: in reference to the analysed impact indicators and parameters, environmental effects resulting from in-house food consumption are higher by 3 to 19% for an allocation of 100%. The influence of the allocation method may be demonstrated in particular for greenhouse gas emissions (8%), formation of particulate matter (9%), soil acidification (19%) and agricultural land use (18%) (Figure 8).

Figure 8: Influence of allocation method (IHC)



[75] http://www.capri-model.org/.

Source: own research.

Furthermore, findings need to be analysed in the light of simplifications and assumptions. It must be borne in mind that results for animal products are based on the assumption that the production of feed components in all countries producing animal products for the German market is the same as in Germany. This implies in particular that import countries and shares are assumed to be the same. This approach especially influences findings for the national origins of land and water use for animal products, and the share of Germany is clearly overestimated as a consequence. Other possible effects in connection with differing harvesting volumes and farming practices are changes in the total of environmental burdens.

An analysis of the origins of water consumption must additionally take into account that no statistics were available on the provenance of rice consumed in Germany. Available data indicate the origin of processed rice products such as husked rice. A significant proportion comes from Belgium which demonstrably is no rice producer. So the largest rice-exporting countries worldwide were assumed to be the largest rice producers for German imports as well, and their share in German rice imports was assumed to equal their global market share. More detailed figures on rice production for the German market might therefore influence the percentage from Pakistan in particular as the largest rice exporter worldwide.

## 3.5 Summary and conclusions from the environmental perspective

Greenhouse gas emissions from German food consumption account for about 23% of the entire annual emissions in Germany; food losses alone cause greenhouse gas emissions that correspond to roughly 4% of Germany's entire emissions.[76]

Water consumption to produce food consumed in Germany corresponds to about one third of water used in German households[77], which is about half the volume of Lake Starnberg outside Munich.[78] Water consumption due to food losses corresponds to about one fifth of the entire water used in Germany, which is about twice as much as the water taken from Lake Constance for drinking water treatment per annum.[79]

The agricultural land used to produce the food consumed in Germany corresponds to 60% of the surface area of Germany, and food losses account for almost 20%, which roughly corresponds to the area of Lower Saxony.[80] It must, however, be noted that not all food losses are avoidable – Kranert et al. assume that about half of all losses in private households may be avoided – and that water is used not only in Germany but worldwide and that agricultural land for the production of food for German consumption is located not only in Germany but distributed over the globe.

Food losses, either avoidable or unavoidable, cause almost half a ton of greenhouse gas emissions per capita and year in Germany, and they account for the use of more than 500 square metres of land

[76] It should be noted that two different approaches are involved here. The sum of German emissions is determined in the process of emissions reporting for the national context, whereas this study includes emissions accrued worldwide in upstream production steps into greenhouse gas emissions resulting from German food consumption. The Federal Environment Agency reports a total of 953 million tons of greenhouse gas emissions for Germany in 2013 (http://www.umwelt-bundesamt.de/daten/klimawandel/treibhaus-gas-emissionen-in-deutschland).

[77] According to the National Association of Energy and Water Industries BDEW (www.bdew.de) 129 l water were used per capita and day in 2010.

[78] http://de.wikipedia.org/wiki/Gr%C3%B6%C3%9Fenordnung_%28Volumen%29; last checked 30 July 2014.

[79] Between 125 and 130 million cubic metres are taken from Lake Constance for drinking water supplies every year. Compare http://de.wikipedia.org/wiki/Gr%C3%B6%C3%9Fenordnung_%28Volumen%29 last checked 30 July 2014.

[80] http://www.statistik-portal.de/statistik-portal/de_jb01_jahrtab1.asp; last checked 30 July 2014.

and of approximately 2.700 l water. Extrapolated to Germany[81] this accounts for 38.340 kilotons of greenhouse gas emissions, more than 43.000 square kilometres of agricultural land and 216 million cubic metres of water.

Results from the eco-balance analysis per kilogram food reveal that products of animal origin have a higher potential environmental impact compared to plant-based products for almost all analysed impact categories and parameters, with the exception of water consumption which is higher for plant-based products. This is particularly evident for agricultural land use: the production of one kilogram of animal-based foodstuffs requires eight times more land compared to plant based products. Differences are also evident in terms of greenhouse potential (four times as high). Consequently, animal products cause higher environmental burdens compared to plant-based products in the area of food losses as well.

With the objective in mind to avoid and reduce food losses, the following conclusions may be drawn from the environmental perspective:

- Food losses from animal products involve far higher environmental burdens compared to losses from vegetable products; priority should therefore be given to avoiding them.
- The proportion of food losses per product consumed is notably higher in OHC compared to IHC. Good housekeeping practices, efficient planning and/or other formats of provision are relatively simple measures to reduce food losses in this sector. Reduction measures should therefore be considered with priority in this sector.
- Efforts should be made in OHC to provide a better database for food consumption (analogous to EVS) so that the proportion of food losses can be determined more effectively and developments can be better monitored.
- As a rule, fresh products (such as seasonal asparagus) involve smaller losses due to spoilage. Elimination of long and multistage supply chains helps to reduce the environmental impact of consumed food.
- Value chains are very long for some foodstuffs and cover many stages. As a consequence, the environmental impact of a food product increases with each stage of processing and/or transport. Avoiding the loss of one kilogram of potatoes prepared by consumers has a greater effect than avoiding the loss of one kilogram of potatoes in agricultural production. It should therefore be a priority to avoid losses of products with a long value chain.
- Available data on food losses specifically at the food processing stage are very unsatisfactory. A rational prioritisation of measures to reduce food losses in terms of their ecological relevance necessarily requires detailed figures on quantities differentiated according to stages in the value chain and types of food. The same applies to the food trade, where no data are available on waste quantities differentiated according to the type of waste.

[81] German population as per 31 March 2013: 80,5113 million (Federal Statistical Office): https://www.destatis.de/DE/ZahlenFakten/GesellschaftStaat/Bevoelkerung/Bevoelkerungsstand/Tabellen/Zensus_Geschlecht_Staatsangehoerigkeit.html;jsessionid=212A52746774489AB08B26FD8314216B.cae1

# 4 Derivation and review of suitable prevention measures

## 4.1 Requirements placed on possible instruments and measures

This project is to identify measures and instruments which can be expected to achieve an effective reduction of the relevant amounts of food waste. These measures and instruments should be fundamentally suited to being included in the Waste prevention programme of the German government with the involvement of the Federal *Länder* (German WPP).

In a first step, a set of requirements to be placed on such "suitable instruments and measures" was developed. In a second step, both established measures/instruments from secondary sources and measures developed by the authors of the present study were assessed on the basis of this set of requirements.

Quite different aspects are relevant for such a set of requirements. In the following, various aspects and possible criteria are discussed, taking the goals presented at the beginning as a starting point:

### 4.1.1 Relevance in terms of amounts

The instruments and measures are to address relevant amounts of food waste.

Such relevance can be expressed in absolute amounts, whereby one must differentiate clearly between absolute amounts at the level of the various stages of the value-added chain (e.g., food manufacturing, wholesaling and retailing, OHC) and the absolute amount per individual place where waste occurs.

While in the first case, the level of private households is "relevant," in the second case, this would be true more of individual large food processing businesses or OHC.

From the perspective of promising implementation of waste prevention measures, high absolute amounts of waste are of less interest than high (relative) waste rates, as the latter give significantly more reason to assume exploitable potential for waste reduction. Such waste rates describe the relationship between the amount of food waste occurring at a particular point and the amounts of food originally used as input at that point.

The amounts used as inputs and the amounts of waste at the various stages of the value-added chain, which have been brought together in this project, permit identification of these loss rates. Even though this data is clearly imprecise, it does reveal significant differences.

Table 43: Overview of average loss rates per stage of the value added chain

| Stage of the value-added chain | Loss rates [average %] |
|---|---|
| Manufacturing | approx. 1 - 15% |
| Wholesaling | approx. 0.05 - 1% |
| Retailing | approx. 0.4 - 8% |
| Away-from-home consumption | approx. 34% |

Compilation of data by authors

From this perspective, OHC would be particularly relevant or promising for appropriate measures and instruments.

In addition, the different loss rates of various product groups would be interesting when prioritizing the development of prevention measures. If, for example, a disproportionate amount of animal-based

food waste were to occur in wholesaling and retailing, then this would significantly increase the relevance of this stage of the product life cycle from an environmental perspective (see below). Such differentiated information on the actual composition of the amounts of waste at the various places of occurrence is, however, not available.[82]

### 4.1.2 Environmental relevance

On the basis of life cycle analyses in the context of this project, an estimate of the environmental relevance[83] can be assigned to the food losses occurring at the various stages of the value-added chain.

As is the case with all life cycle approaches, the multidimensional nature of environmental impacts must be taken into account. Yet the results can be summarized in two simple truths:

- The later in its life cycle a food occurs as waste, the higher the environmental burden aggregated within it, i.e., the more relevant it is to prevent this waste.[84]
- From an environmental perspective, preventing waste of meat and dairy products clearly has the highest relevance.

The following figure shows the differences in environmental impacts of plant-based and animal-based foods across their life cycles in a direct comparison.

[82] It should be pointed out here that although the assessment of the environmental relevance of food waste do include such breakdowns of the amounts of waste by product groups (chapter 3), these are assumptions on the part of the authors of the present study. Real data on the composition of waste at the various stages of the value-added chain/places of occurrence is not available to date.

[83] As described in the relevant sections of this report, this is explicitly an assessment for purposes of orientation, since the overall life cycle analysis naturally required a large number of assumptions, determinations, and simplifications both from a methodological perspective and with a view to the available basic data.

[84] However, in the case of food, this effect is distinctly weaker than in the case of most other (technical) products, since significantly fewer resource-intensive transformation or processing operations occur at the various stages of food processing. This means that above all, the impacts from transportation and storage (relevant in the case of cold chains) and of course the (yield) losses add up over the course of the life cycle, but that the total environmental impact is dominated by the original agricultural production.

Figure 9: Comparison of the evaluations of plant-based and animal-based foods on the basis of life cycle assessment

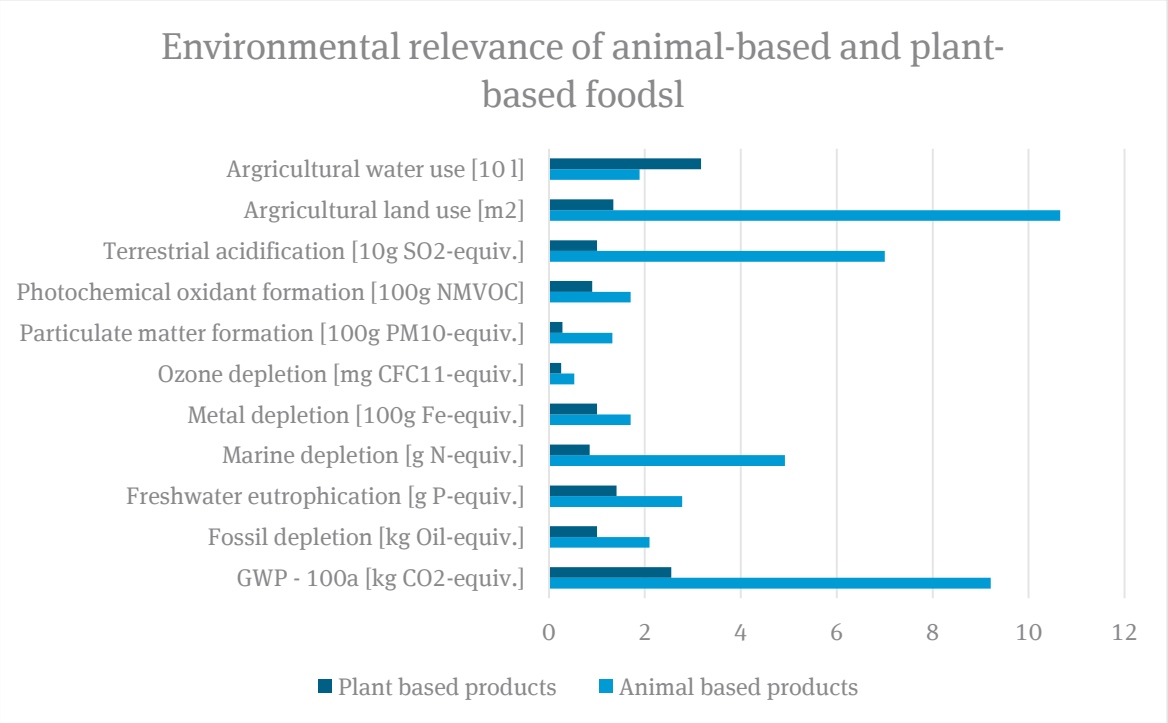



Diagram by authors

### 4.1.3 Initiator/actor and target group

As outlined above, the measures and instruments developed in the present project are to be fundamentally suitable to being taken up when implementing and/or updating the German WPP. It was adopted for the first time in July 2013 by the German government in accordance with the provisions of § 33 Para. 5 KrWG (Circular Economy Act, *Kreislaufwirtschaftsgesetz*)[85] and is to be updated periodically.

The German WPP is not directly binding for third parties, but is considered to be only an internal administrative instrument, i.e., an internal obligation on the part of the responsible state agencies and other public-law entities.[86] In addition, inclusion in the German WPP does not in itself result in the implementation of a prevention measure; instead, active implementation by possible initiators is still necessary in each case.

Since requests posed to third parties thus have a non-binding character or the character of an appeal, the desired "effective reduction" in the area of food waste presumably requires clear self-binding on the part of public-law actors.

In other words, the instruments and measures to be identified are to be both initiated and implemented by state actors.[87] This means that the initiator and thus the actor acting first should also be a

85 BMUB 2013.

86 Schomerus in: Versteyl; Mann; Schomerus 2012: § 33, marginal number 5; also of this view Petersen; Doumet; Stöhr 2012: 521, 528.

87 It should be mentioned in this context that one of the food waste prevention measures recommended in the current German WPP (section 4.1, Recommended measures, p. 29) includes such clear self-binding only in a limited form. It

state actor. The target groups of a measure can also be found in the business community or civil society.[88]

### 4.1.4 Type and binding nature of the instruments used

The type and binding nature of the implementation of measures depend on the implementation instruments available or employed. In principle, state actors can take binding actions by means of three different types of instruments, in particular by using

- regulatory instruments
- financial or fiscal-policy instruments
- information and communication instruments.

Concerning the instruments' time horizons and the binding nature of their implementation, the authors are of the opinion that one must differentiate between the use of existing instruments and the creation of new ones. Thus, the following possible instruments emerge in descending order of short-term, binding implementation:

- State agencies agree to use existing legal provisions to enforce waste-preventing action in a binding manner.[89]
- State agencies take the initiative to adopt new legal provisions to prevent waste or to make existing ones more concrete.
- State agencies expand the application of existing financial instruments to include (food) waste prevention activities.
- State agencies use existing dialogue and negotiation processes with trade associations and market actors to agree on targeted (binding) obligations to implement waste prevention measures.
- State agencies use existing dialogue and communication processes with the business community and the public for activities to inform and raise awareness about questions of (food) waste prevention.
- State agencies initiate new dialogue and communication processes to disseminate information and raise awareness about questions of (food) waste prevention.

In the context of state action, the question also arises as a matter of principle as to the level at which action can and should be taken. In other words, the question whether institutions at the federal, the *Länder*, or the municipal level should take on the role of initiator and/or acting initiator of a measure.

However, the discussions between the federal government and the *Länder* about the proper and efficient allocation of tasks in the various spheres of activity when further implementing the German WPP have not (yet) progressed to a stage[90] that a clear criterion for sorting/allocating the screening of suitable measures could be derived thereof.

Discussions between the authors and representatives of the *Länder* suggest that the *Länder* would like the federal level to provide orientation regarding a possible determination and concretization of

merely recommends that concerted actions and agreements between public institutions and the business community "are to be encouraged."

88 This could be the case, for example, for a binding waste prevention enforcement measure in the area of monitoring installations.

89 This may include, among other things, public procurement procedures, but also permitting of installations, etc.

90 It should be taken into account here that clear allocations of competencies exist in many spheres of application of the law, possibilities to initiate new laws, and also the funding environment.

minimization goals as well as a common discussion about ways of soundly monitoring the achievement of objectives. In addition, some *Länder* agencies consider it necessary for dialogues and negotiations with the retailing community to be conducted at the federal level. The high market concentration in the retailing sector with only a few business groups operating across Germany makes opportunities for negotiation processes at the *Länder* level appear less promising.

However, concerning concrete individual measures and information campaigns or, e.g., inclusion of the topic of food waste prevention in education both within and outside schools, the *Länder* that have taken action in this regard do see themselves in a position of being able to undertake effective implementation steps.

### 4.1.5 How the measures work

Naturally, waste prevention measures differ in terms of the ways in which they take effect.

Some measures directly reduce the occurrence of waste when they are implemented. They include, e.g., measures that "force" mandatory use of a new, less waste-intensive process technology or handling practice. This type of direct prevention effect is also to be assumed if purchasing or procurement standards are introduced that define ambitious caps on the actual waste rates of the goods in question.

In addition, other measures tend to create frameworks that stimulate or support a more careful and less waste-intensive way of handling food. They include, for example, interventions in the underlying economic conditions which make it more attractive to use a higher percentage of foods or which require businesses to create information systems that provide interested customers with concrete information about the waste rate of the manufacturing or processing operation in question and thus can stimulate demand in a targeted fashion.

Furthermore, there is a broad range of measures aiming to improve awareness of and appreciation for food overall, thus indirectly contributing to reducing the occurrence of food waste. They certainly include educational and experiential projects such as urban gardening, nutritional education at schools, and many others.

In accordance with its overarching goal, this project focuses on measures with a strong binding nature that result in direct and/or indirect prevention of relevant food waste.

### 4.1.6 Qualified assessment of the measures

The extraordinary relevance of food waste prevention for environmental protection—according to the ecological assessments conducted, the production of foods that are not used in the end is responsible for global greenhouse gas emissions corresponding to about 5% of total greenhouse gas emissions in Germany—also legitimizes in principle binding regulatory interventions in the production, marketing, and use of foods.[91]

However, such interventions always require enabling legislation, and they must be in accordance with the national requirements (especially conformity with fundamental rights) and EU law (especially compatibility with the Single Market). All interventions must also observe the principle of proportionality. That means that the intervention in question must be suitable, necessary (no less invasive means are possible), and appropriate (proportional in the narrower sense).

In order to do justice to these requirements, it is necessary to be able to assess the effect of a measure in advance. Such an evaluation requires a good understanding of the way in which the measure

[91] The SRU, for example, arrives at this conclusion in its Environmental Report 2012 (cf. Ch. 3.5, p. 115ff).

works and a well-founded assessment of the extent of its application, especially also a well-founded information base concerning the actual amounts of waste and their composition at the various stages of the value-added chain and at the various places where waste occurs.

**Excursus to explain the data/information necessary for valid assessments of effectiveness**

*In order to evaluate the (environmental) relevance of a waste prevention measure, data and/or valid estimates regarding each of a number of interlinked facts are required. The following example illustrates this, using a list of questions:*

- *Which places where waste occurs are addressed by the measure in principle? (e.g., all state-run cafeterias)*
- *What amounts of waste occur there now, differentiated according to the different types of food, each with their own environmental relevance? (e.g., x kg/a pork, y kg/a veal, z kg/a tomatoes from Spain, etc.)*
  *=> This presupposes differentiated information on the amounts of waste occurring, relating to a large number of waste generators.*
- *How many of the principally covered places where waste occurs are actually expected to implement/carry out the measure? (e.g., in xy% of the cafeterias)*
- *Which percentage of the wastes occurring there to date can be prevented by the specific measure? (e.g., a% for meat, b% for vegetables, c% for pasta)*
  *=> This presupposes differentiated information about each of the processes by which wastes occur.*

*On the basis of the data/information outlined, the expected amount of the different types of food waste prevented because of implementation of the measure can be calculated, and on this basis, the overall environmental effect. This positive prevention effect must then be weighed against possibly occurring additional burdens (of an economic or ecological nature).*

Yet precisely such information is clearly lacking to date. That is why especially those measures resulting in a better information base are very important. However, the implementation of such instruments, which should be called secondary measures (without prevention effects of their own), can be a prerequisite for the feasibility of the directly effective and binding reduction measures.

### 4.1.7 Template for reviewing and describing measures

A template for reviewing and describing measures was derived from the requirements and aspects outlined above, which are analyzed more concretely in the context of the present project. The template is used to evaluate measures proposed in secondary studies.

Table 44: Template for reviewing and describing potentially suitable measures

| Level of characterization | Description of the concrete measure |
|---|---|
| Starting point in the life cycle | A brief description is given here of the stage in the value-added chain which the measure uses as a starting point (agriculture, food production, wholesaling/retailing, OHC or IHC or overarching) and whether it potentially addresses only selected product groups. |
| Description of how the measure works | The measure is classified as having direct or indirect effects, and the basic way in which it works is outlined. |

| Level of characterization | Description of the concrete measure |
|---|---|
| Type of instrument | The proposed instrument is classified as legal, providing funding, and/or informative.<br>In addition, the time horizon of the measure's possible implementation is characterized. |
| Initiator | In the case of state actors, the levels of government (EU, federal government, *Länder*, municipalities)<br>In the case of business community actors, the stage of the value-added chain (agriculture, food manufacturers, wholesalers/retailers, OHC businesses) |
| Target group(s) | See initiator |
| Relevance/potential of the measure for waste prevention | Relevance of implementation of the measure in terms of amounts and the environment |
| Information concerning possible follow-on effects (economic and social) | E.g., labor market effects or significant price increases |

Representation by authors.

## 4.2 Existing policy goals and programs for preventing food waste

### 4.2.1 EU level

The "Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan" (SCP/SIP Action Plan) was intended to integrate the dimension of sustainability in the EU's industrial policy alongside the growth and employment goals realized in the context of the Lisbon Strategy. The SCP/SIP Action Plan declares sustainability to be a key political goal of the EU: "The **core of the Action Plan** is a dynamic framework to improve the energy and environmental performance of products and foster their uptake by consumers."[92] However, it does not include any concrete measures relating to the prevention of food waste.

The goal of increasing resource efficiency is detailed further in the flagship initiative A Resource-Efficient Europe under the Europe 2020 Strategy[93] (COM(2011) 21). Food is mentioned explicitly as an important topic.[94]

The flagship initiative is concretized in the Resource Efficiency Roadmap. It identifies nutrition, besides housing and mobility, as a key sector "to addressing the challenges in energy and climate

[92] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan COM(2008) 397 final: p. 3. Available at http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52008DC0397&from=EN, last accessed 21 October 2014.

[93] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy COM(2011) 21. Available at http://ec.europa.eu/resource-efficient-europe/pdf/resource_efficient_europe_en.pdf, last accessed 21 April 2015.

[94] This is in line with, for example, the results of the EIPRO study (2006), which elaborated that the production of food is one of the sectors with the greatest negative environmental impacts.

change"[95] and consequently sets out a concrete milestone: "By 2020, incentives to healthier and more sustainable food production and consumption will be widespread and will have driven a 20% reduction in the food chain's resource inputs. Disposal of edible food waste should have been halved in the EU."[96] This goal was to be implemented by a Communication from the Commission on sustainable food by 2013 at the latest, which is still outstanding (see below); the development of a methodology for sustainability criteria for important foods by 2014 at the latest; a Green Paper on the sustainable use of phosphor by 2012; and by calling on Member States to include food waste in their national WPPs.

In parallel, the general prevention goals for waste from households (Art. 9) mentioned in the revised European Waste Framework Directive[97] (EWFD) also apply to food waste. Even though food waste accounts for a significant proportion of total household waste, no specific prevention goals for food waste were defined in the EWFD.

In the 7th Environment Action Programme[98] adopted in 2013 by the European Parliament and the Council, the Commission is also called upon to "present a comprehensive strategy to combat unnecessary food waste and work with Member States in the fight against excessive food waste generation."

The European Parliament also expressed its view in a resolution on food waste: "Avoiding food wastage—European Parliament resolution of 19 January 2012 on how to avoid food wastage: strategies for a more efficient food chain in the EU."[99] In this resolution, the Parliament addresses the Commission, the Council, and the Member States with 35 points including various determinations and appeals, and assigning various tasks. Among other things, this resolution "[u]rges the Council and the Commission to designate 2014 the European Year against Food Waste, as a key information and awareness-raising initiative for European citizens and to focus national governments' attention on this important topic, with a view to allocating sufficient funds to tackle the challenges of the near future" (point 35).

With regard to the "European Year against Food Waste," neither the Commission nor the Council followed the suggestion of the EP; instead, they pledged to take action with other measures in this area to curb food wastage.[100]

At the initiative of the then Environment Commissioner *Stavros Dimas* and the Consumer Protection Commissioner *Meglena Kuneva*, a voluntary Retailers' Environmental Action Programme (REAP) was launched on 3 March 2009 together with representatives of EuroCommerce and the European Retail Round Table (ERRT) to implement the Sustainable Consumption and Production Action Plan[101], and

---

95 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Resource Efficiency Roadmap COM(2011) 571 final: p. 17. Available at http://ec.europa.eu/food/safety/food_waste/library/docs/com2011_571_en.pdf, last accessed 21 October 2014.

96 p. 18.

97 Directive 2008/98/EC.

98 Decision No. 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet' OJ EU of 28 December 2013 No. L 354 p. 171. Available at http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013D1386&from=EN, last accessed 28 October 2014.

99 "Avoiding food wastage. European Parliament resolution of 19 January 2012 on how to avoid food wastage: strategies for a more efficient food chain in the EU (2011/2175(INI)) Available at http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+TA+P7-TA-2012-0014+0+DOC+PDF+V0//EN, last accessed 21 April 2015.

100 Written information from the press attaché of the EP, Jens Pottharst, 28 October 2014.

101 COM(2008) 397 final (see footnote 92).

within this framework a "Retail Forum" on sustainability was established.[102] The forum works on overcoming important environmental problems, including the reduction of food wastage.

At the October 2012 annual meeting of the Retail Forum, which 23 retailers and two retail associations[103] have joined by now, a retail agreement on waste[104] was signed in which retailers agreed to engage in at least two awareness-raising initiatives on waste reduction by mid-2014.

The overriding goal of the "European Retail Action Plan"[105] adopted by the Commission in 2013 is to address the "key obstacles to achieving a Single Market in Retail by setting out a strategy to improve the competitiveness of the retail sector and enhance the sector's economic, environmental and social performance." Under the subgoal of developing a more sustainable retail supply chain, the European Retail Action Plan also seeks to achieve a reduction of food waste: "*In the context of existing EU Platforms, the Commission will support retailers to implement actions to reduce food waste without compromising food safety (awareness raising, communication, facilitating of redistribution to food banks, etc.) e.g., through the Retail Agreement on Waste; and work on developing a longterm policy on food waste, including a Communication on Sustainable Food to be adopted in 2013.*"[106]

This Communication by the Commission on sustainable food, which was actually planned for 2013, was not yet been published at the time of completion of the present study (January 2015). The same is true of the results of a public consultation process[107] conducted by the Directorate-General for Environment in the summer of 2013, with more than 600 responses by trade associations, NGOs, and citizens.

In addition, three studies were commissioned in this context:

- DG Environment's background study "The Sustainability of the Food Chain—an appraisal of the European food cycle with respect to resource use and emissions to the environment,"[108] in which existing EU policy and the topics it lacks are analyzed.
- the report of the Standing Committee on Agricultural Research "Sustainable food consumption and production in a resource-constrained world,"[109] in which an approach across sectors and Member States is called for, and
- the "Preparatory Study on Food Waste across EU 27,"[110] which examines the causes of the problem of food waste and which was evaluated in the present report (see Ch. 4.5).

---

102 http://ec.europa.eu/environment/industry/retail/about.htm, last accessed 27 October 2014.

103 http://www.eurocommerce.be/policy-areas/environment/policy-updates/2012/20121009-retail-agreement-on-waste/retail-agreement-on-waste.aspx, last accessed 27 October 2014.

104 http://www.eurocommerce.eu/media/54887/retail-agreement-on-waste-updatedjune2013.pdf, last accessed 23 April 2015.

105 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions European Retail Action Plan. COM(2013) 36 final: p. 4.

106 Ibid.: p. 13.

107 http://ec.europa.eu/environment/consultations/food_en.htm, last accessed 28 October 2014.

108 http://ec.europa.eu/environment/eussd/pdf/foodcycle_Final%20report_Dec%202012.pdf, last accessed 28 October 2014.

109 http://ec.europa.eu/research/agriculture/scar/pdf/scar_feg3_final_report_01_02_2011.pdf, last accessed 28 October 2014.

110 Monier et al. 2009.

Finally, the results of the FUSIONS project (Food Use for Social Innovation by Optimising Waste Prevention Strategies) were taken into account in an expert workshop.[111]

On 23 September 2014, the Commission published an impact assessment as a working paper[112] which includes recommendations for reducing the amount of food waste, among other things. In it, the problem of waste is placed within the overarching topic of a "sustainable food system," which is defined as follows:

*"For food, a sustainable system might be seen as encompassing a range of issues such as security of the supply of food, health, safety, affordability, quality, a strong food industry in terms of jobs and growth and, at the same time, environmental sustainability, in terms of issues such as climate change, biodiversity, water and soil quality."[113]*

The report also states: "Currently there is no food waste prevention strategy in place at EU level, although there are some relevant measures being undertaken. Many Member States are currently taking little or no action, and food waste levels are increasing."[114]

In order to bring about a reversal of the trend of increasing amounts of waste, the report recommends improving knowledge and awareness of the consequences of wastefulness, influencing handling practices, and supporting waste prevention measures as well as a corresponding transformation in the market for food.[115]

Besides awareness-raising and financial measures, in particular the concrete recommendations to the Commission to make existing policies and legislative initiatives more precise and more uniform should be mentioned here:

**Making policy more precise and more uniform: [116]**

- "Clarify the EU VAT Directive for donation of surplus food to food banks"
- "Encourage best-practice in relation to food date labels by food business operators to minimise wastage."
- "Develop EU Food Donation Guidelines for food donors and food banks on how to comply with the EU Food Hygiene legislation"
- "Agree a common EU definition of food waste"
- "Develop a standardised methodology for collecting and reporting data on food waste to ensure data comparability across Member States."

**"Legislative options:" [117]**

- "Introduce reporting requirements on food waste."
- "Set binding targets for food waste prevention."

---

111 Financed by the 7th Framework Programme of the European Commission (FP7), this project is running from 2012 through 2016.

112 Commission Staff Working Document. Impact Assessment on Measures Addressing Food Waste to Complete SWD (2014) 207 Regarding the Review of EU Waste Management Targets. SWD(2014) 289 final. Available at http://ec.europa.eu/environment/archives/eussd/pdf/IA.PDF, last accessed 8 April 2015.

113 Ibid.: 4f.

114 Ibid.: 23.

115 Ibid.: 24.

116 Ibid.: 25.

117 Ibid.: 25.

- "Set aspirational targets for Member States to prevent food waste."

The extent to which these recommendations from the working paper will be taken up in the Communication of the Commission and in binding EU policies was still open at the time of completion of the present report.

However, in its Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions "Towards a circular economy: A zero waste programme for Europe,"[118] the EU Commission proposed "that Member States develop national food-waste prevention strategies and endeavour to ensure that food waste in the manufacturing, retail/distribution, food service/hospitality sectors and households is reduced by at least 30% by 2025".

### 4.2.2 Waste prevention programme of the German government with the involvement of the Federal *Länder* (German WPP)

The German WPP implements the requirements of the WFD at the national level. The legal basis for a WPP in accordance with the requirements of Art. 29 FWD is provided by § 33 Circular Economy Act (KrWG). The first German WPP was prepared as of 12 December 2013. It is evaluated every six years and updated as needed.

Concerning food waste, the German WPP does not mention any specific prevention goals (Ch. 3.3), and the goals for other types of waste are generally qualitative, not quantitative. The main goal is "the decoupling of economic growth from the impacts on humans and the environment due to waste generation."[119] One operative goal toward attaining the main goal refers to the "reduction of the amount of waste"; various subgoals, in turn, are derived from this.

On the basis of these goals, waste prevention measures are recommended; they include, among others, two recommendations referring specifically to food waste:

- **Waste prevention measures in businesses**
  "With a view to preventing food waste, concerted actions and agreements between public institutions and industry/retail and distribution are to be encouraged in order to minimize food waste occurring along the production and supply chain. The goal is to take the entire value-added chain—i.e., not only consumer behavior—into consideration in order to reduce food waste."[120]
- **Waste prevention measures on the part of consumers**
  "Information campaigns will be initiated or continued as an important element of raising consumers' awareness about aspects of waste prevention. Campaigns regarding waste prevention when shopping (amounts, package sizes, best-before dates, reusable packaging) will play an important role in this context. In the area of food waste, the program of the Federal Ministry of Food and Agriculture (BMELV) "Too good for the bin" ("*Zu gut für die Tonne*") can be mentioned as a positive example."[121]

---

[118] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions "Towards a circular economy: A zero waste programme for Europe" of 2 July 2014 (COM/2014/0398 final). Available at http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52014DC0398&from=EN, last accessed 20 April 2015.

[119] BMUB 2013: Waste Prevention Programme of the German government with the involvement of the Federal *Länder* (*Abfallvermeidungsprogramm des Bundes unter Beteiligung der Länder*) 20.

[120] Ibid.: 30.

[121] Ibid.: 31.

In the final chapter, the German WPP discusses existing measures that can affect the underlying conditions relating to waste generation (Appendix 4 No. 1 of the KrWG). These are described and evaluated with a view to further implementation. They include three measures referring directly to food waste:

- Measure 17: Voluntary agreement with the retailing and hospitality industries on training measures with a view to achieving closer alignment of supplying stores and restaurants with food on the one hand with actual demand on the other.[122]
- Measure 18: Agreements between industry/trade and government agencies on waste prevention. The agreements may concern various waste streams, for example food waste.[123]
- Measure 28: Concerted actions to prevent food waste[124]

Measures 17 and 28 are recommended for implementation; in the case of measure 18, it is recommended to examine the effectiveness of concrete cases.

Thus, the German WPP does not include any quantitative goals for food waste prevention to date, and the recommended measures are all of a voluntary nature.

## 4.3 Activities at the federal level

A key starting point was the study by the University of Stuttgart[125], which has already been quoted numerous times in the present report and which concluded that industry, wholesaling and retailing, large-scale consumers, and private households discard just under 11 million tons of food as waste per year, corresponding to 81.6 kg per capita and year in Germany.

The initiative "Too good for the bin" aiming to raise awareness and appreciation of food was launched by the Federal Ministry of Food and Agriculture (BMEL) in late March 2012. In principle, this campaign addresses the entire chain of food manufacturing and use, but it addresses end consumers in particular, including students.

The main information portal for this initiative is on the BMEL website (in German only).[126]

Besides numerous activities across Germany to raise awareness among end consumers, the following areas were the subject of activities on the part of the BMEL under the umbrella of the initiative:

- the best-before date
- food waste prevention in hospitals
- waste prevention in the hospitality industry
- food donations to food banks (manual on donating food to social welfare institutions)[127]

Many of these activities were conducted in 2012. Significantly more current activities are to be found on the information portal for end consumers[128], where a large number of practical tips for shopping for food and for stocking, cooking, and storing it are provided for consumers.

---

122 Ibid.: 55 f.

123 Ibid.: 56.

124 Ibid.: 66.

125 Kranert et al. 2012

126 http://www.bmel.de/DE/Ernaehrung/UmgangLebensmittel/ZuGutFuerDieTonne/node.html.

127 It is available at https://www.zugutfuerdietonne.de/uploads/media/LeifadenWeitergabeLMSozEinrichtungen.pdf.

128 https://www.zugutfuerdietonne.de/start/ (in German)

To date, the Federal Environment Ministry (BMUB) does not call attention to any activities of its own in relation to the topic of food waste. However, a relevant representation of the climate relevance of food production, including concrete reference to the climate benefits of organic agriculture, is to be found.[129]

## 4.4 Activities at the level of the *Länder*

The issue of food losses/food waste prevention has been discussed quite intensively in recent years in many *Länder* as well. In particular a large number of information portals and information campaigns are to be found there. They predominantly address end consumers, especially including children and youths. Appendix I provides an overview and orientation about such information campaigns with keywords referring to the sponsors, contents, and the target groups in question.[130]

Some *Länder*, including North Rhine-Westphalia[131], Baden-Wuerttemberg[132], Bavaria[133], and Saxony[134], have also commissioned studies of their own on the baseline situation and/or possible reduction measures.

A discussion about possibly coordinating efforts of the *Länder* regarding potential reduction goals within the framework of a national strategy is currently underway in the context of the *Länderarbeitsgemeinschaft Verbraucherschutz* (Consumer protection working group of the *Länder*, LAV), in which the Healthy Diet and Nutritional Information Working Group (*Arbeitsgruppe Gesunde Ernährung und Ernährungsinformation*, AG GEE) is preparing recommendations for decisions for the Conference of Consumer Protection Ministers (*Verbraucherschutzministerkonferenz*, VSMK).[135]

## 4.5 Evaluation of existing proposals for measures from secondary studies

A number of relevant secondary studies were evaluated with the goal of identifying suitable measures to be examined in more depth. The approach and key results of these evaluations are described in the following sections.

### 4.5.1 Approach for conducting research on the basis of the secondary studies

The following studies were included in the evaluation:

- Göbel et al. (2012): *Verringerung von Lebensmittelabfällen – Identifikation von Ursachen und Handlungsoptionen in Nordrhein-Westfalen* (Reducing Food Waste – Identification of causes

---

129 Cf. http://www.bmub.bund.de/themen/wirtschaft-produkte-ressourcen/produkte-und-umwelt/produktbereiche/lebensmittel/.

130 In addition, there is an abundance of further campaigns and actions supported by civil-society or business actors, e.g. by the Center for Ecology and Development (*Kontaktstelle für Umwelt und Entwicklung*, KATE e.V.) Berlin; Foodsharing.de; the app FoodLoop, which is still under development; Foodfighters; the German Nutrition Society (*Deutsche Gesellschaft für Ernährung*, DGE); SlowFood; the Heinrich Böll Foundation (Meat Atlas 2014 Extra); the initiative "A better day the 100 way" ("*Ein guter Tag hat 100 Punkte*"); the "Leftover Calculator" ("*Resterechner*") developed by the Verbraucher Initiative e.V., Berlin (a consumer organization); the project "*ESSEN MACHT …—mehr als satt & mächtig*" ("Food makes you …—more than satisfied and powerful") of *BUNDjugend NRW* (the North Rhine-Westphalia youth section of the *BUND* (Friends of the Earth Germany)), to mention but a few.

131 Cf. Göbel et al. 2012.

132 Cf. Knappe; Reinhardt; Diebel 2013.

133 Cr. Kern 2014.

134 Here, the Saxon State Ministry of Social Affairs and Consumer Protection (*Staatsministerium für Soziales und Verbraucherschutz* (SMS) commissioned a study on the topic "Representation and evaluation of food waste prevention measures for the Free State of Saxony—food waste prevention measures," which is being conducted by consultants from INTECUS and Ökopol and is scheduled for completion by the end of 2015.

135 Personal communication, Ms. Tyra, Chair, LAV-AG GEE, 22 January 2015.

and courses of action in the German State of North Rhine-Westphalia). iSuN Fachhochschule Münster University of Applied Sciences.
- Gustavsson et al. (2011): Global food losses and food waste. FAO Rome.
- Knappe; Reinhardt; Diebel (2013): *Ideen für mögliche Maßnahmen zur Abfallvermeidung in Baden-Württemberg* (Potential measures for waste prevention in Baden-Württemberg). LUBW Karlsruhe.
- Kranert et al. (2012): *Ermittlung der weggeworfenen Lebensmittelmengen und Vorschläge zur Verminderung der Wegwerfrate bei Lebensmitteln in Deutschland.* (Determination of discarded food and proposals for a minimization of food wastage in Germany) University Stuttgart, Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA)
- Lipinski et al. (2013): Reducing Food Loss and Waste. World Resources Institute Washington.
- Marthinsen et al. (2012): Prevention of food waste in restaurants, hotels, canteens and catering. Nordic Council of Ministers
- Monier et al. (2010): Preparatory Study on Food Waste in the EU 27. Final Report. BioS/ UBA/ AEA.
- Priefer; Jörissen; Bräutigam (2013): Technology options for feeding 10 billion people -Options for Cutting Food Waste. ITAS. Karlsruhe.
- German Advisory Council on the Environment (*Sachverständigenrat für Umweltfragen*) (2012): Environmental Report 2012. Berlin.
- Stenmarck et al. (2011): Initiatives on prevention of food waste in the retail and wholesale trades. Nordic Council of Ministers. Copenhagen.
- Waarts et al. (2011): Reducing food waste. Obstacles experienced in legislation and regulations. LEI report 2011-059. The Hague.

In the selection of these studies, it was decisive that

- they were up-to-date at the time of work on the present project,[136]
- they were prepared in the context of supraregional deliberations on food waste prevention, thus providing a fundamentally transferable framework of analysis,
- they derive and present potential prevention measures in a well-founded manner,
- they include proposals for measures addressing state actors.

These studies include proposals for measures that appear fundamentally suitable according to the aspects of section 4.1 for being able to make a contribution to effectively reducing relevant food wastes and that could be suitable for implementation in the context of the German WPP. They were identified and analyzed using a uniform template for description (cf. section 4.1.7). The template was applied to a total of 113 measures in this step.[137]

### 4.5.2 Results of the evaluation of secondary studies

In the following step, a (comparative) evaluation was undertaken, based on the individual evaluations (descriptive template applied to proposals for measures). This comparative evaluation involved some fundamental methodological and substantive difficulties. For example, the various studies on the topic did vary significantly in terms of their degree of detail.[138] Marked differences in terms of

[136] i.e., that they were prepared in late 2013/early 2014.

[137] This was documented in a work report as an intermediary outcome of the present project.

[138] They ranged from political-strategic concepts from a kind of bird's eye perspective to quite concrete, yet also very small-scale deliberations regarding optimization.

fundamental linguistic-definitional aspects became apparent as well; this refers not only to the question of the definition of food waste[139], but also, e.g., to what was considered a "measure" to prevent food waste in a particular study.[140] Naturally, there were also relevant differences with a view to the temporal and spatial frames of reference.[141]

#### 4.5.2.1 Limited number of substantive approaches

Despite the difficulties outlined, the comparative evaluation showed clearly that a fairly limited number of different substantive approaches are behind the high number of individual proposals.[142] These substantive approaches can be differentiated as follows, for example:

Measures for (policy) design of underlying conditions:

- Setting prevention goals
- Improving the data on food waste
- Increasing the economic value of food and food waste
- Mandating waste prevention action on the part of businesses in the food sector

Measures on concrete individual aspects:

- Supporting food bank concepts
- Adapting (waste-generating) marketing standards
- Optimizations in the food sector for which the businesses themselves are responsible
- Changing the best-before date to prevent waste
- Labels for low-waste products
- Adapting hygiene standards in OHC to prevent waste
- Consumer-oriented portion sizes in OHC
- Designing and using packaging to prevent waste
- Changing waste disposal

Measures to increase appreciation of food:

- Information campaigns on waste prevention
- Integration of waste prevention in education and further education
- Small-scale/regional structures for (direct) marketing

Other measures:

- Dialogue and cooperation projects on waste prevention
- Financially supporting research on waste prevention solutions
- Supporting low-waste food handling in developing countries

Further, comparatively far-reaching bundles of measures include:

---

139 E.g., waste in accordance with the KrWG; amounts not eaten which could be eaten, etc.

140 Various descriptions are to be found here that tend to identify starting points or outline potential instruments, or that focus on actor constellations required for effective action.

141 While some proposals for measures, for example, target the entire EU market, others address very specific regional features of food manufacturing and distribution.

142 This is due in particular to the fact that many of the available studies refer to other studies. However, only some of them explicitly mention this fact. As a result, identical proposals for measures, which are presented slightly differently, are often to be found.

- the proposal to establish a (state-financed) agency[143] that bundles and implements such measures (comparable, e.g., to WRAP[144] in the UK)
- the proposal for all relevant authorities to work together and coordinate measures[145]
- bundling several measures toward the ambitious goal of "zero avoidable food waste"[146].

#### 4.5.2.2 Predominantly vague or non-binding instruments

A comparison of the number of measures that tend to be non-binding, i.e., voluntary measures and measures involving appeals or information, to that of legally binding measures reveals that a distinct majority of proposals are of a less binding nature.[147] In addition, in the case of most of the proposed measures aiming at binding legal rules and regulations, it remains unclear or open how they can or should be translated into binding legal form.

That the instruments developed are “vague,” i.e., undifferentiated, arises from the fact that practically all of the measures proposed to date are theoretical approaches that are not based on practical experience with implementation. This has particularly serious consequences for the overall goal of researching measures, namely “to identify effective measures toward the reduction of relevant amounts of food waste” because it means that it is not possible to gain any insights about the practical efficacy and potentially existing difficulties in implementation by evaluating the secondary studies.

## 4.6 Development of measures on the basis of available legal instruments

### 4.6.1 General approach

Precisely because the legal and instrument-related aspects have been elaborated only fairly vaguely in the secondary studies on food waste prevention measures available to date, or their transferability to the German situation is very limited, the authors of the present study also reviewed legal possibilities and available instruments parallel to researching existing proposals for measures in secondary studies, as outlined above. The following steps were taken:

- definition of a framework for analysis as well as potential starting points for reviewing legal instruments; review of the extent to which existing (environmental) rules and regulations can be applied to the area of food manufacturing and use, and whether these legal instruments can help achieve the various fundamentally intended effects ("functions"), i.e., for example, the obligation to gather differentiated data or to apply "good" (here: waste-preventing) handling practice.
- derivation of how government agencies can employ the existing legal instruments to induce the actors in question to undertake concrete waste prevention actions which were identified as reasonable and relevant in the context of the "starting points."
- elaboration and evaluation of concrete proposals for measures on the basis of the previous steps of the analysis, including the evaluation of the secondary studies and the discussions with experts in the relevant fields, including in the context of the expert meetings.[148]

---

143 Cf. Lipinski et al. 2013: 30.

144 http://www.wrap.org.uk/.

145 Cf. Stenmarck et al. 2011: 36.

146 Cf. Marthinsen et al. 2012: 105f.

147 In concrete figures, the shares of such initiatives in Europe are approx. 21% information campaigns and approx. 12% information instruments and training (Monier et al. 2010).

148 In particular in the expert workshop "Food losses and food law," which was conducted in the framework of the project on 4 April 2014 at Leuphana University of Lüneburg, and in the expert meeting "Preventing food waste—Assessment,

### 4.6.2 Framework and starting points for the analysis

Food waste in the sense of waste law, which is the object of the German WPP's prevention efforts, occurs only in very small amounts in agricultural production. One reason for this is that agricultural products become "foods" only after completion of original production. Another is that harvest losses, waste from sorting activities, and the like are not declared and disposed of as waste in the practice of agricultural operations, but are directly reintroduced into the agricultural processes through composting and other measures.

For this reason, agricultural products suitable for eating[149] that remain "in the fields" can be addressed only indirectly by means of waste prevention measures. This would be the case, for example, if measures (e.g., an adaptation of the established trade standards or the like) had effects reaching back to the stage of agricultural production and permitted access to an additional market opportunity that would make it unreasonable to farmers to plow crops under.

In light of the environmental relevance of original agricultural production, agricultural "losses" are taken into account in a targeted fashion in the present project in the evaluation of the environmental relevance of food consumption. For the reasons mentioned, however, this area is not analyzed further to derive prevention measures induced by waste law.

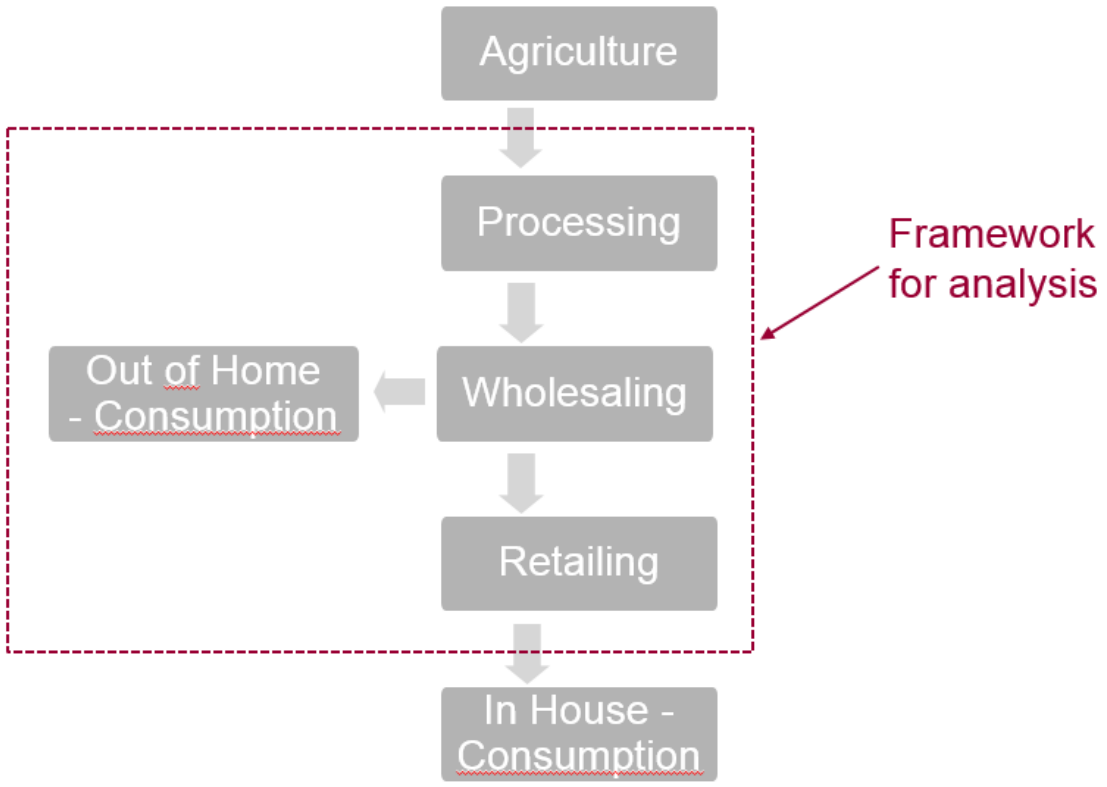
This analysis also does not focus on activities taking place exclusively at the level of the end consumer (i.e., in private households) since no opportunities for direct regulatory interventions in end consumers' behavior are seen. However, it does include measures taken by state actors, such as information campaigns and educational measures, that aim to change the awareness and thus the behavior of end consumers.

Thus, the framework of analysis presented in the following emerges to identify suitable measures:

proposals for measures, and starting points from the environmental perspective" on 24 June 2014 at the Federal Press Office in Berlin.

149 Regardless whether they had already attained the legal status as "food."

Figure 10: Framework of analysis for the identification of possible government-initiated prevention measures




Representation by authors.

In order to go beyond this in a targeted manner in the research and the deliberations on developing suitable prevention measures, the authors used the insights gained in the context of the orienting environment-related assessment to identify points where measures making an effective contribution to preventing food waste could and should begin. These starting points can be differentiated, among other things, according to the target groups in question, such as agriculture, processors, wholesalers, OHC, retailers, and private households (IHC).[150]

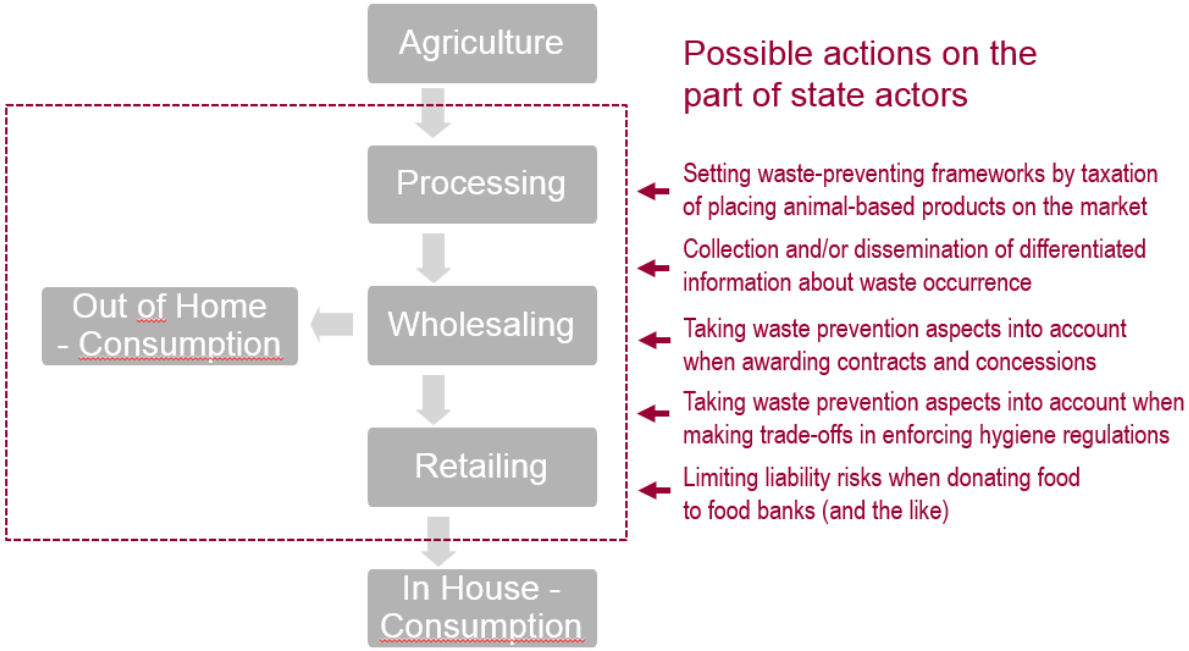
Relevant starting points for **waste prevention action on the part of state actors** are to be found in the following areas:

- Change of underlying economic conditions by state agencies, who then provide incentives to the market actors to prevent food waste;
- Gathering, processing, and circulation of differentiated information on food waste occurrence and composition by state agencies;
- Consideration of waste aspects when state agencies award contracts and concessions;
- Obligation for state agencies to take waste prevention aspects into account in making trade-offs in the enforcement of food-hygiene requirements;
- Support for the donation and use of edible foods that would otherwise become wastes (in particular food bank concepts) by reducing legal (liability) risks with the help of state agencies.

[150] Besides the differentiation according to possible initiators—it was already discussed above that the initiator of a measure should be a state actor—precise characterization of the target groups and their special features to which the various measures must be tailored matters.

The following figure gives an overview of these starting points for state agencies:

Figure 11: Possible starting points for state actors to prevent waste




Representation by authors.

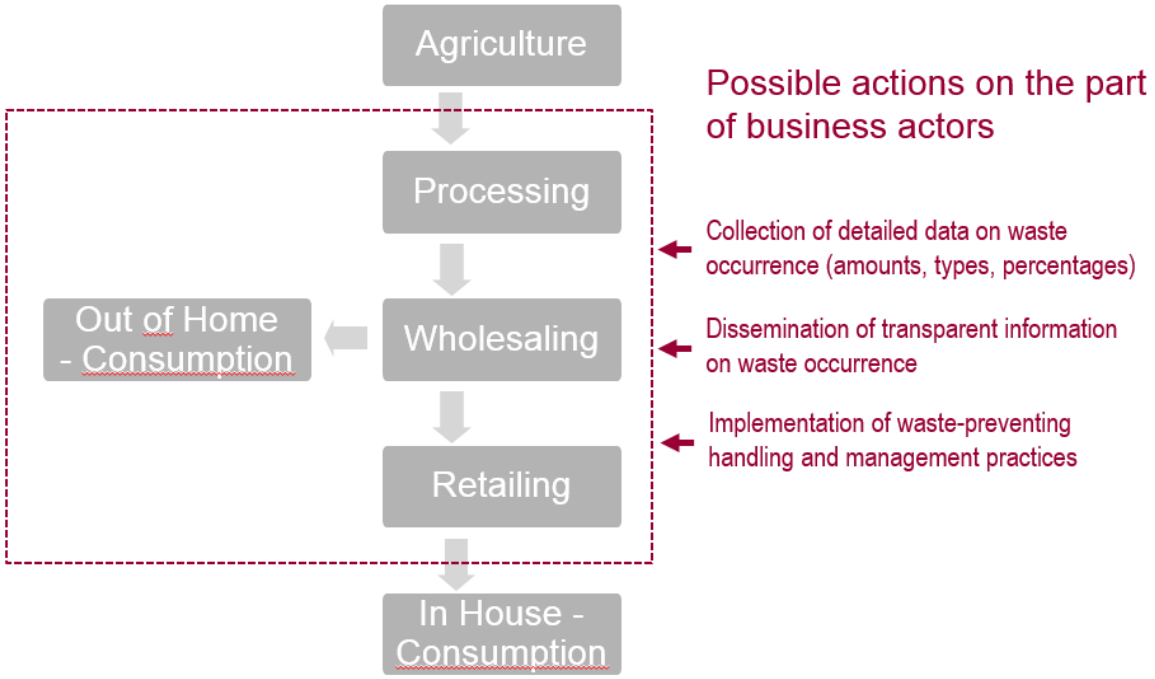
Relevant starting points for actions by business-community market actors to prevent waste which can be stimulated by state initiatives are to be found especially in the following areas:

- Gathering of detailed data on waste occurrence (amounts, types, rates) by the business-community market actors,
- Circulation of transparent information on waste occurrence by the business-community market actors,
- Implementation of waste-preventing handling and management practices by the business-community market actors.

The implementation of waste-preventing handling and management practices is the key activity that business-community market actors can undertake. The other two approaches to action are, however, necessary preconditions for taking up the significance and the effectiveness of such actions in a well-founded manner.

The following figure gives an overview of these starting points:

Figure 12: Possible starting points for business actors to prevent waste




Representation by authors.

Thus, as a result of these basic preliminary considerations, especially such measures are to be identified or developed that

- are initiated by state agencies,
- have a direct or a clear indirect waste-preventing effect, or that, as secondary measures, provide the necessary information for impact assessment,
- can be corroborated quantitatively in terms of effectiveness and appropriateness, and
- that induce waste-preventing actions on the part of state and/or business actors in terms of the starting points outlined above with a high degree of bindingness.

### 4.6.3 Allocation of existing legal instruments to various starting points

In the following, key aspects of the legal review of existing legal instruments conducted in the present project are presented in terms of their suitability for binding implementation of waste prevention measures at the starting points derived above.

#### 4.6.3.1 Suitability of existing instruments to mandate commercial actors to gather differentiated waste data

**Circular Economy legislation**

The instrument of waste management concepts and balance sheets in accordance with § 21 KrWG[151] applies only to public waste disposal authorities. It does not apply to food waste prevention. Requirements for private actors to gather data on waste amounts and to prepare balance sheets existed up until the changes in the Waste Avoidance, Recycling and Disposal Act (KrW-/AbfG) in 2005 and 2007

[151] KrWG = Circular Economy Act (*Kreislaufwirtschaftsgesetz)*

for waste requiring special supervision (§§ 19, 20 KrW-/AbfG, Ordinance on Waste Management Concepts and Waste Balance Sheets, AbfKoBiV); since then, waste law has no longer included such requirements. *De lege ferenda*, one could image an "Ordinance on Waste Management Concepts and Waste Balance Sheets for Food-Processing Operations" in accordance with §§ 23 ff. KrWG. However, the applicability of the KrWG to food is questionable. Expansion of the powers to issue statutory instruments in § 24 KrWG would presumably be required. Yet doubts exist with regard to conformity with fundamental rights (Art. 3, 12, 14 Grundgesetz), particularly concerning proportionality.

**Immission control legislation**

For installations subject to permitting, there exists a requirement to prevent waste in accordance with § 5 Para. 1 No. 3 BImSchG (Federal Immission Control Act, *Bundesimmissionsschutzgesetz*), which also covers food losses. When granting a permit, the permitting authority can in principle impose a requirement to gather data. For installations not subject to permitting, which make up the majority of the food-processing operations in question, this would require the adoption of a statutory instrument in accordance with § 22 Para. 1 Sentence 2 BImSchG. The obligations concerning food loss prevention can be concretized in BAT (best available technology) reference documents.

#### 4.6.3.2 Suitability of existing instruments to mandate business actors to implement good management practices

**Immission control legislation**

Whether waste prevention measures can be based on the rules and regulations on product responsibility in accordance with the KrWG is questionable, as described above. Building on the BImSchG is more easily conceivable. It could form the basis for an obligation for operations manufacturing/processing food to implement "good management practices." In the case of installations subject to permitting, such implementation is possible in form of a duty of the operator in accordance with § 5 Para. 1 No. 3 BImSchG (waste prevention), potentially also via § 5 Para. 1 No. 2 BImSchG (duty to take precautions). Model administrative regulations, BAT reference documents, or the like could make these duties more concrete. In the case of installations not subject to permitting, which comprise a larger number of installations, the adoption of a statutory instrument in accordance with § 22 Para. 1 Sentence 2 BImSchG would be necessary, as discussed above. This places strict requirements on conformity with fundamental rights, in particular concerning proportionality.

**EMAS, ISO 14001**

Food losses can be prevented by means of environmental management systems when purchasers use an obligation under private law to require them of their suppliers in the supply chain.

#### 4.6.3.3 Suitability of existing instruments to mandate business actors to label products

**Ecodesign Directive**

Under current law, the Ecodesign Directive is not applicable to food, because food is not used, but consumed (used up). While expanding the directive to food might be imaginable *de lege ferenda*, political and administrative reasons would block this from becoming a reality. The situation for food packaging could be different, as it could in principle be addressed by the Ecodesign Directive as a product relevant fact in terms of energy consumption.

**Labelling Directive**

"Low-waste production" is conceivable as a food label. *De lege lata*, the Labelling Directive is linked to the Ecodesign Directive, which to date has not been applicable to food (see above). *De lege ferenda*, an expansion of the Labelling Directive would make sense only if the Ecodesign Directive were expanded at the same time. The question should also be raised as to the indicators for low-waste production/processing that could be used if labelling is introduced.

#### 4.6.3.4 Possibilities for state agencies to gather/circulate information on food losses

According to the Consumer Information Act (*Verbraucherinformationsgesetz*[152], VIG), claims to access to information regarding data on food losses do not exist, since the law relates to health, but not to the environment and thus not to waste, either.

According to the Environmental Information Acts (*Umweltinformationsgesetz*[153], UIG) at the federal and the *Länder* level, in contrast, such claims may exist, since conceptually speaking, the data on food losses is environmental information. However, these claims refer only to data held by agencies, not to data held by private food-processing businesses. The Environmental Information Acts also establish active information obligations (see § 10 Federal UIG) concerning food losses. Compared with the Freedom of Information Acts at the federal and the *Länder* levels (*Informationsfreiheitsgesetz*[154], IFG), the UIGs are more suitable from the perspective of the claimants for gaining access to information about food losses.

The Environmental Statistics Act (*Umweltstatistikgesetz*, UStatG) permits surveys in the form of federal statistics for purposes of environmental policy. The surveys are conducted only for installations subject to permitting which treat or dispose of waste. There is no separate survey for food processing businesses. *De lege ferenda*, an expansion of § 4 UStatG could provide for surveys on the disposal of food waste.

### 4.6.4 Evaluation of the instrumental design of possible measures

Based on the review of instruments above, the authors of the present study developed possible instruments for key starting points for mandatory food waste prevention and performed an initial evaluation of them in terms of their appropriateness and (political) chances of success. The results of these steps are documented in the following.

#### 4.6.4.1 Obligation of business-community waste generators to determine the amounts and composition of wastes

**Description of the starting point**

The lack of differentiated data on the specific amounts of waste occurring[155] and their composition (by main waste fraction) is a substantial obstacle to further analysis of the relevance of the amounts of waste and the environmental relevance of the various areas where waste occurs within the different steps of the value-added chain. For example, no analyses of which types or forms of OHC are particularly relevant in terms of waste exist. As described above, surveys in accordance with the Environmental Statistics Act do not provide data on the occurrence and treatment of food waste, but

[152] Gesetz zur Verbesserung der gesundheitsbezogenen Verbraucherinformation, 05.11.2007 (BGBl. I S. 2558)

[153] Umweltinformationsgesetz , 22.12.2004 (BGBl. I S. 1643)

[154] Gesetz zur Regelung des Zugangs zu Informationen des Bundes, 05.09.2005 (BGBl. I S. 2722)

[155] Amounts of food waste in relation to food input in the processes in question.

merely general information on amounts of bio-wastes. Thus, a well-founded basis for proper derivation of focused concepts for food waste prevention is lacking, as well as, in part, the basis for reviewing specific regulatory interventions in terms of their proportionality.

In order to change this unsatisfactory situation, appropriately differentiated obligations for commercial actors in the manufacturing/wholesaling/retailing food chain to determine and document data could be a suitable measure.

**Potential regulatory intervention**

Such obligations to determine and document data could be based on the obligations of operators laid down in § 5 Para. 1 No. 3 BImSchG, as described above. In particular, the federal government could adopt a statutory instrument for installations not subject to permitting in accordance with § 22 Para. 1 Sentence 2 BImSchG according to which the obligations to prevent waste in accordance with § 5 Para. 1 No. 3 BImSchG would also apply to certain installations not subject to permitting, e.g., in the field of food processing.

To obtain informative statements which could guide actions, one would have to determine the input of upstream products besides waste occurrence at a particular point. Only on this basis is it possible to ascertain waste rates that would enable an assessment of relevance in comparison with operations of the same type or also with other steps of the life cycle. To this end, the determination of the waste rate would also have to be addressed via the operators' obligations of the BImSchG.

**Challenges:**

**Substantive challenges**: Proper interpretation of the absolute amounts of waste and the corresponding waste rates requires good knowledge about the processes in question and the opportunities and limits to waste prevention they involve. In addition, the preceding and following processes must also be analyzed in order to be able to take existing interrelationships into account. For example, processing less standardized upstream products may result in somewhat higher amounts of waste, while this may have a significantly positive effect in the preceding step.

**Regulatory challenges**: Since the legal requirements would refer only to residual fractions considered to be waste in accordance with the KrWG, this could potentially induce evasive behavior, e.g. manufacturing lower-value "by-products" or using imprecise declarations (selection of other waste codes or the like). In addition, it appears necessary to introduce a requirement, as appropriate, to keep different main fractions apart (especially wastes from animal-based and plant-based upstream products), going beyond the separation requirements prevailing in waste management to date.

**Administrative challenges**: Mandatory preparation and circulation of waste occurrence documentation would require considerable time and effort on the part of companies and public agencies. Both actors might have to hire additional personnel, adapt their data processing, etc.

**Possible less invasive alternatives**

Gathering data for a limited period of time, across a limited area, and for a limited number of features might be sufficient to derive proper prevention measures. For example, it is reasonable from an environmental perspective to focus in a first step on waste from the production, marketing, and processing of foods with animal-based upstream products.

This type of focused data-gathering obligations could be brought about by means of the legal instruments reviewed. A suitable way of doing this would be to incorporate them in the environmental statistics surveys in accordance with the UStatG, which can take place via the power to issue statutory instruments in § 17 b) UStatG, as described above.

Another alternative could be a voluntary commitment by the food sector to gather data. With a view to the high degree of (environmental) relevance of the topic overall, exacting requirements are to be placed concerning the representativeness of the sectors/processes/businesses included, the degree of detail of the information gathered, and in particular the transparency and traceability of the data compiled. Therefore, one must consider whether such a voluntary commitment on the part of the food sector or voluntary agreements with state actors such as the responsible Federal Ministry of Food and Agriculture (BMEL) are possible in Germany.

The successful implementation of such a voluntary approach in the UK in the context of the Courtauld Commitment has highlighted interesting perspectives of how a cooperative approach by producers, wholesalers and retailers, and public administration can handle the practical challenges pragmatically.[156]

**Conclusion**

In principle, the starting point of an obligation to determine the amounts and composition of waste occurring in businesses can be implemented on the basis of existing legal instruments (esp. BImSchG). However, it will presumably not be easy to justify the proportionality of the necessary implementation steps (e.g., adoption of a statutory instrument in accordance with § 22 BImSchG) and the time and effort required for enforcement for "merely" gathering basic data. Although the environmental impacts in connection with food waste occurrence overall undoubtedly justify far-reaching regulatory interventions, the information base available to date does not permit sound assessment of the relevance of individual types of operations or sectors of the food sector.

From the perspective of the authors, gathering detailed data on a cooperative basis and/or with a limited temporal or spatial scope should be favored at present. This can be realized by self-regulation in the form of a unilateral commitment on the part of the business actors or by a bilateral agreement with the responsible state actors such as the BMEL.

#### 4.6.4.2 Obligation to create transparency about the occurrence of food waste (labeling products in terms of waste generation)

**Description of the starting point**

Market actors and end customers who are aware of the topic and would therefore like to purchase low-waste products are faced by the problem that they do not receive any information about the waste relevance of various upstream products.

**Potential regulatory intervention**

[156] Cf. on this the deliberations in section 4.3.4; it should, however, be taken into account that the situation in the UK cannot be transferred directly to Germany. The key question is how to enter into a binding dialogue between the political community, public administration, the food sector, and wholesalers and retailers. In light of the very strong market concentration in (food) retailing in the UK, there is both pronounced negotiation power and strong competition between the remaining market actors. The heterogeneity of the German trade association landscape in the food-manufacturing sector, in contrast, brings about challenges in the identification of partners with correspondingly strong negotiation power in order to conclude such a voluntary commitment.

Even today, the Environmental Information Acts at the federal (UIG) and the *Länder* levels in particular allow for sufficient rights to access to information, provided concrete applications are submitted and the authorities actually have the information. However, the authorities currently do not have this information. The necessary breadth of specific information would be available to the authorities only in the context of implementing measures to establish such an obligation to gather and document data (cf. above). Yet even in this way, only information on places/areas of waste occurrence would become available, but not information on individual products.

A more targeted way of informing consumers would be an obligation to provide (cumulative) waste rates on the products in question (labeling requirement). Such labeling requirements could be realized via an expansion of the scope of the Ecodesign Directive to include food, followed by the adoption of corresponding statutory instruments to implement labeling. It appears doubtful whether this could be realized, however, since the EU legislator would have to take action, but has rejected expanding the scope of the Ecodesign Directive to include food products to date. As an alternative, a specific basis in EU law might come into consideration, as in the case of the Energy Labelling Directive (2010/30/EC)[157]. A decision-making process at the EU level, with the goal of creating a corresponding legal basis, logically in the form of an EU directive, requires comprehensive, EU-wide, and time-consuming coordination for which the political will has not been apparent to date.

These labeling regulations could be realized in the style of energy labeling in accordance with Directive 2010/30/EC.

**Challenges:**

**Substantive challenges**: In order to enable proper comparative interpretation of the waste rates indicated on labels, a large number of concretizations and assumptions relating to processes, fractions of upstream products and residual waste, allocation rules in the case of mixed manufacturing processes, and the like would be necessary. In addition, it is imperative to note that the characteristic of a food product as low-waste usually by no means correlates with other (environmental) qualities of the product in question (e.g., with a view to a healthy diet, organic cultivation standards, or other sustainability aspects). In individual cases, conflicts of goals may even arise. It is doubtful whether interested end consumers can grasp this complexity.

**Regulatory challenges**: A labeling requirement would be reasonable only if it were to address all products brought to market in the same way (independently of their origins). This implies a far-reaching intervention in the market (barrier to entry) which must be consistent with fundamental principles of the rule of law, in particular the principle of proportionality. For example, such a measure might be considered no longer appropriate if waste occurrence in manufacturing, wholesaling, and retailing is fairly small, even after detailed examination.

**Administrative challenges**: A labeling requirement is reasonable only if it is accompanied by corresponding monitoring of the market to avoid free riders. Since such waste rates are not product characteristics, but process characteristics, such monitoring is quite difficult and requires considerable time and effort (not least in the case of imported products).

**Possible less invasive alternatives**

[157] Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products (recast), published in the Official Journal of the European Union on 18 June 2010. OJ L 153, 18.6.2010, p. 1–12

Besides labeling requirements, systems for voluntary labeling of low-waste products are imaginable. But here too the necessity arises to elaborate a comparatively intricate routine of data gathering and monitoring, as well as the significantly weightier aspect that, as discussed above, the low-waste characteristic of a product, considered in isolation, does not yet amount to meaningful information for consumers from an environmental (and nutritional) perspective.

**Conclusion**

Even though relevant legal authorizations for mandating voluntary or obligatory "waste labeling" of foods exist, the authors do not consider such a step expedient for the reasons outlined above (in particular the danger of misinterpretation).

From the authors' point of view, it appears more meaningful to review whether and how waste relevance is to be included in more comprehensive sustainability labels.[158]

#### 4.6.4.3 Obligation of businesses in the food sector to implement good management practice

**Description of the starting point**

The information available to date points to the fact that especially in the area of OHC, some waste rates are very high[159]. Reference analyses[160] show that they are due to excess quantities and leftovers that could be reduced significantly by optimizing planning and handling. Yet implementation of good management practice can also be an effective starting point for business actors in food processing, wholesaling, and retailing to reduce the amounts of food waste.

**Potential regulatory intervention**

Implementation of good management practices can be made obligatory by concretizing the relevant duties of operators laid down in the BImSchG. Since it can be assumed that OHC operations as a rule are installations not subject to permitting, a statutory instrument in accordance with § 22 Para. 1 Sentence 2 BImSchG expanding the obligation to prevent waste as set out in § 5 Para. 1 No. 3 BImSchG would be necessary.

In addition, a (model) administrative regulation would have to be drawn up (or available handling manuals would have to be transposed into the relevant status). A starting point for this could be the General model administrative regulation of the LAI on the prevention, reuse and disposal of wastes in accordance with § 5 Para. 1 No. 3 BImSchG *(Allgemeine Musterverwaltungsvorschrift des LAI zur Vermeidung, Verwertung und Beseitigung von Abfällen nach § 5 Abs. 1 Nr. 3 BImSchG)* of 2005. Compliance with these requirements would then have to be monitored in the context of installation monitoring for the OHC operations they involve.

Such monitoring would be significantly easier if the descriptions of good management practice included requirements relating to handling practices as well as reference values for residual waste rates

---

158 As the environmental assessments carried out in the context of the present study have shown, the specific amount of waste (at least when using differentiated life cycle inventory data) is reflected clearly in various categories of environmental impacts. I.e., one would have to discuss in the context of sustainability labels whether waste relevance should be an indicator on its own or be included in a different category.

159 The analyses in this project (cf. section 3) show an average waste rate of 33.5% in this area.

160 For example, the findings of the projects by FH Münster University of Applied Sciences on the topics "Reducing food waste concerning bread and baked goods—Developing a concept for wholesaling and retailing, crafts and trades, and consumers" as well as "Reducing losses and disposal of goods in away-from-home catering—A contribution to increasing resource efficiency."

in line with actual practice that are to be achieved when implementing good handling practices. Relevant deviations of the real waste rates[161] from these reference values would then have to be discussed, or the operator would have to give valid reasons for them. The corresponding reference values must take account of the different underlying conditions in the various types of operations in OHC, i.e., a differentiated system of reference values would have to be prepared.

For the area of food manufacturing operations, corresponding requirements for management practice are imaginable as well. They too can be formulated either in the form of a description of good handling and management practice or as reference values. Here, a sector- and process-specific approach should be taken. Some of the reference descriptions and values can be laid down in the BAT (best available technology) reference documents if it has been regulated how these requirements, which are to be monitored directly only for IED (Industrial Emissions Directive) installations, are also to be made obligatory for non-IED installations (for example, via a statutory instrument in accordance with § 22 Para. 1 Sentence 2 BImSchG).

**Challenges:**

**Substantive challenges**: The fundamentals for informative presentations of good management practice (or the best available technology) and the corresponding reference values must be elaborated in a highly differentiated manner for the various types of operations, processing operations, and forms of marketing/serving food. Active, cooperative collaboration with a correspondingly large number of businesses is necessary for this process.[162]

**Regulatory challenges**: To date, there are no examples that could serve as references for the transfer of waste prevention obligations from installation operators in accordance with § 5 Para. 1 No. 3 BImSchG to installations not subject to permitting[163], which would be required to implement this measure; i.e., this would mean breaking new regulatory ground.

The process to concretize the waste prevention obligations of installation operators, in particular through relevant model administrative regulations to be elaborated by the LAI or corresponding ATV-DVWK-Advisory Guidelines[164], has been practically on hold for almost ten years.

The questions as to the concrete form of such guidance documents for implementation and enforcement and the bodies which are to prepare them are currently under discussion in the framework of the ongoing implementation of the requirements of the Industrial Emissions Directive (IED).

**Administrative challenges**: If the focus is placed on parts of the sector characterized by a very large number of smaller businesses, e.g., small restaurants and fast food outlets, then the danger arises that a disproportional amount of time and effort will be spent on securing and monitoring compliance with good management practice, both for operators and supervisory authorities.

**Possible less invasive alternatives**

---

161 On the obligation to gather data cf. measure "Verpflichtung zur Ermittlung von Anfallmengen und Abfallfraktionen bei den gewerblichen Abfallerzeugern."

162 The results available to date from individual studies of businesses used as examples should be called into question in terms of their broad transferability to other cases, both because of the relatively small numbers of businesses and because the businesses participating in the studies tended to be proactive pioneers.

163 Via a statutory instrument in accordance with § 22 Para. 1 Sentence 2 BImSchG.

164 ATV = *Abwassertechnische Vereinigung* (Wastewater Technical Association); DVWK = *Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall*; today *Deutsche Vereinigung für Wasserwirtschaft, Abwasser, und Abfall e.V.* (DWA, German Water Association), see http://de.dwa.de/faq1.html.

In principle, guidance documents for implementing good management practice can also be prepared for purely voluntary use by the businesses in question. In addition, implementation of good handling practice can also be supported by establishing (environmental) management systems in companies.

It is an open question whether a large number of businesses in the food sector would actually use and effectively implement such supporting measures. Although it is true that studies of individual examples show time and again that businesses can even achieve positive effects by implementing waste prevention measures, there is no evidence at present that maintaining handling routines for waste prevention can be organized to be economically self-sustaining under the prevailing highly competitive conditions of the food sector.

**Conclusion**

This starting point, namely an obligation of businesses in the food sector to implement good management practices, can be implemented quite well with the existing legal instruments (BImSchG). However, its implementation necessitates careful elaboration of relevant and informative Advisory Guidelines or model administrative regulations, and therefore resources for the required analyses of the situation in the various sectors of the food industry as well as the preparation and coordination of the documents.

#### 4.6.4.4 Use of fiscal policy measures to increase the appreciation of animal-based foods

**Description of the starting point**

The environment-related assessments show quite clearly (again) that animal-based foods (milk, eggs, and meat) should be handled and used with particular care with a view to their high environmental burden. A corresponding impulse addressing the entire value-added chains could be generated by significantly increasing the price of animal-based foods.

**Potential intervention**

An example of such a fiscal-policy intervention could consist of targeted taxation of the use or the concentration of animal-based upstream products in foods. The SRU, for example, also calls for the use of such fiscal-policy instruments in its Environmental Report 2012.[165]

In Germany, this could be implemented at the federal level in the form of a consumption tax on the basis of the competencies in accordance with Art. 106 Para. 1 No. 2 Grundgesetz. The above-mentioned SRU report, which examines the introduction of a "tax on saturated fatty acids" from, inter alia, a constitutional-law perspective, arrives at an initial positive evaluation of its permissibility in terms of constitutional law. The SRU considers it a Pigouvian tax, which could be a suitable instrument especially in the case of market failure in the area of environmental or health protection. One prerequisite is the suitability of the tax for reaching the goal, in this case a reduction in the consumption of saturated fatty acids. In the case of low price elasticity of demand, suitability might be called into question, for example if consumers continue to consume the product to the same extent as before despite such a tax. Then, the desired steering effect would not be achieved.[166]

A measure that could serve as a reference was implemented in Denmark.[167] In this case, the concentration of saturated fatty acids in foods was used as the reference value for taxation, with particular

[165] SRU 2012: pp. 118 ff.

[166] Ibid.: p. 119.

[167] Cf. on this the deliberations in section 4.3.3.

reference to possible negative health effects. This "fat tax" was abolished after a few months with reference to an insufficient steering effect because of a lack of political acceptance. However, hardly any substantial findings from studies on the question of the steering effect in Denmark are available. The data gathered there reflects mostly the transitional phase immediately following the introduction of the tax. Because of the brief duration of this reference model, the authors consider it problematic to transfer the findings to market conditions once the situation has settled down.

**Challenges:**

**Substantive challenges**: To date, the concentration of animal-based upstream products is not included in legal labeling requirements. Yet reference points for taxation are to be indicators that are as distinct[168] as possible and easy to operationalize. In addition, in particular the price elasticity of demand for the products containing animal-based upstream products should be examined very carefully in order to achieve a maximum steering effect with minimal additional costs (with a view to the social and overall political aspects).

**Regulatory challenges**: New taxes/fees introduced for environmental reasons can be implemented only with great difficulty in the existing political landscape, especially if they have to be substantial to achieve the desired steering effect.

**Administrative challenges**: From the perspective of legal enforcement of the tax, in particular an easy-to-verify indicator/reference value for the concentration of animal-based upstream products would be relevant. Yet in light of the large number of channels of commerce and distribution of foods, one would have to reckon with a large amount of time and effort for enforcement, especially if the goal is to ensure that free riders violating the tax regulations do not attain competitive advantages.

**Possible less invasive alternatives**

Less invasive alternatives to induce a general change in the underlying conditions do not exist.

A fundamental transformation of dietary styles and customs resulting in a significant reduction of the amounts of animal-based foods people eat would, however, have a comparable effect.

**Conclusion**

Fundamentally speaking, this starting point can be addressed within the existing legal system. From the perspective of the authors, its evaluation is ambivalent. On the one hand, the research shows that relevant additional steps in analysis and development are necessary for a targeted and proper intervention in the market (including: determination of a valid point of reference and a level of taxation adapted to price elasticity), and that an effective intervention appears difficult to implement for political reasons. On the other hand, no substantial proposals exist how the ecological value of animal-based foods can appropriately be introduced into the economic systems of market and consumer decisions any other way.

[168] Although the indicator used for the Danish fat tax, namely the concentration of saturated fatty acids, correlates fairly well with the percentages of animal-based upstream products in many areas, some plant-based upstream products, e.g., palm oil and coconut oil, also contain relevant percentages of saturated fatty acids.

#### 4.6.4.5 Taking waste prevention aspects into account in the enforcement of food-hygiene requirements

**Description of the starting point**

Many of the secondary studies evaluated criticize that relevant amounts of food waste occur because of the established practices of food-hygiene enforcement; against this background, they suggest changes to food-hygiene requirements and enforcement practices.[169] These requirements arise in particular from the Food and Feed Law (*Lebensmittel- und Futtermittelgesetzbuch*, LFGB)[170], some of whose content matter comes from the directly applicable EU General Food Law Regulation[171].

Especially in the case of (highly) perishable foods, there are doubtless latent conflicts of goals between the food-hygiene measures necessary to avoid health risks from eating potentially spoiled or contaminated foods on the one hand and the efforts to prevent food waste on the other. The authors of the present study are of the opinion that the established hygiene standards, some of which apply the precautionary principle for good reason, should not be questioned in the absence of a truly detailed technical review. § 1 Para. 1 No. 1 LFGB places preventing and averting dangers to human health at the beginning of the stated purposes of the law. More important than the stated purposes of the law are the concrete rules and regulations relevant to food hygiene, for example the prohibitions for the purpose of protecting health in accordance with Art. 14 Para. 1 of the EU's General Food Law Regulation, according to which foods that are unsafe must not be placed on the market, as well as § 5 LFGB, according to which foods must not be manufactured or prepared for others in a manner that eating them is hazardous to human health.[172]

However, it appears somewhat simpler to work toward the following goal: the aspect of waste prevention should be included when making the required trade-offs in situations where the implementation of food-hygiene requirements provides scope for discretion. § 2 Para. 2 No. 1 a) in conjunction with § 3 Para. 1 KrWG provide the basis for the priority of disposal in accordance with food law over the KrWG with its principle of waste prevention. Yet the LFGB provides neither a uniform, comprehensive legal basis for disposal nor substantive legal requirements for waste disposal, but merely specific disposal rules, such as the power to issue statutory instruments in § 14 Para. 1 No. 3 LFGB in relation to the preconditions under which animal-based foods are to be considered as contaminated with infectious material as well as determining the necessary measures for safe disposal, or the general power in § 34 Sentence 1 No. 1 in relation to the safe disposal of products. That means that whenever there are no specific requirements concerning disposal arising from food law, the KrWG and the principle of prevention enshrined in it apply.

**Possible state measure**

---

169 However, in most cases, the ways in which it is alleged that hygiene standards contribute to generating food waste are not explained at all or only in a very cursory manner. Concrete proposals for changes—which hygiene standard be adapted, and how?—are also mostly lacking. Some concrete proposals identified in the evaluation of the secondary studies are to be found in the compilation in Appendix I in Tabelle 59.

170 Food and Feed Law in the version of its promulgation of 3 June 2013 (BGBl. I p. 1426), last amended by Article 2 of the law of 5 December 2014 (BGBl. I p. 1975).

171 Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety, OJ L 31, 1 February 2002, pp. 1-24.

172 On this, Meyer 2012: § 5, marginal number 1.

The aspect of waste prevention could be integrated systematically in the relevant guidelines[173] for implementation of the food-hygiene requirements as a matter to be taken into account in the decision-taking process.

**Challenges:**

**Substantive challenges**: Even if waste prevention were to be included in the guidelines for the food inspection agencies of the *Länder* as a goal to be taken into account when balancing concerns in discretionary decisions, alongside food-hygiene aspects, this would still involve balancing different concerns in concrete individual cases, which would be very difficult to standardize.

**Regulatory challenges**:

In the practice of food-establishment operations as well as governmental enforcement, sector-specific best-practice guidelines provide orientation for concrete procedures when implementing food-hygiene requirements. Such guidelines are an important element of the concept underlying the European Regulation on the hygiene of foodstuffs[174]. According to that regulation, guidelines can be prepared, developed, and disseminated at the European (Article 9) or the national level (Article 8).

In practice, the majority of guidelines relevant to the various processes of food manufacture and use are prepared or proposed by trade associations at the national level and then are reviewed by the responsible bodies of the *Länder* according to the "procedure for reviewing guidelines for good procedural practice"[175] set forth in Section 5 of the General Administrative Regulation on the performance of official monitoring of compliance with hygiene rules for foods of animal origin and on the procedure for reviewing guidelines for good procedural practice (AVV LmH)[176].

The procedure does not provide for coordination across ministries. Coordination between the *Länder* occurs within the framework of the *Länder* working group on consumer protection, in particular in the working group AFFL[177] for the area of meat and poultry meat hygiene as well as specific questions concerning products of animal origin as well as the working group ALB[178] for (other) foods, materials and articles, wine, and cosmetics. The responsibility for coordinating the entire procedure of coordination and review lies with the German Federation for Food Law and Food Science (BLL); the procedure includes consumer representatives and the specialized agencies Federal Office of Consumer Protection and Food Safety (BVL), the Federal Institute for Risk Assessment (BfR), and the *Friedrich-Loeffler-Institut*—Federal Research Institute for Animal Health (FLI), which are actively involved[179].

---

173 An overview of the national "Guidelines for good hygiene practice" ("*Leitlinien für eine gute Hygienepraxis*"), current as of January 2015, is to be found in Appendix IV of this report.

174 Regulation (EC) No. 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs, OJ EU L 139 of 30 April 2004, p. 1.

175 Depending on the area to which the guidelines apply, different *Länder* are responsible for coordinating this review. These responsibilities are laid down in Appendix 5 to the AVV LmH. For example, Bavaria is responsible for coordination in the area of the food service industry, institutional food services, and fast food outlets.

176 General Administrative Regulation on the performance of official monitoring of compliance with hygiene rules for foods of animal origin and on the procedure for reviewing guidelines for good procedural practice (AVV Lebensmittelhygiene – AVV LmH) of 9 November 2009, last amended by administrative regulation of 20 October 2014 (BAnz AT 07. November 2014 B2).

177 Working group meat and poultry meat hygiene and specific questions concerning animal-based foods (AFFL).

178 Working group food, materials and articles, wine, and cosmetics (ALB).

179 The German Federation for Food Law and Food Science (*Bund für Lebensmittelrecht und Lebensmittelkunde e.V.*, BLL) is the umbrella organization of the German food sector and is based in Berlin; http://www.bll.de/en/home

**Administrative challenges**: Because of the structures and processes, some of which are decentralized and heterogeneous, it is difficult to estimate the additional administrative time and effort required if waste prevention were considered to be a new matter to be taken into account in the decision-taking process.

**Possible less invasive alternatives**

Since the guidelines are the key basis for orientation for enforcing food hygiene on the ground, no alternative is to be seen for integrating waste prevention as an additional matter to be taken into account in this type of enforcement.

**Conclusion**

The authors are of the opinion that this starting point can be implemented very concretely and in a targeted manner. To this end, an expert debate is to be conducted across ministries and including all the above-mentioned actors. In this debate, the participants should jointly review where and how one can do justice to the necessity of reducing the amounts of waste in the formulation and interpretation of the guidelines while maintaining the goals related to protecting food hygiene.

Similarly to the best-practice guidelines, the guiding principles of the German Food Code (DLBK), which are based on the work of the German Food Code Commission (DLMBK), include requirements that are potential obstacles to waste prevention. For this reason, the authors of this study believe that a review of individual guiding principles in terms of this aspect is advisable, following the relevant procedures of the DLMBK's rules of procedure and with the involvement of the Environment Ministry.

#### 4.6.4.6 Limiting liability risks from providing food to food banks

**Description of the starting point**

Wholesalers/retailers giving food away who explicitly point out that the best-before date has passed are directly subject only to a limited liability risk. In accordance with §§ 521 and 524 German Civil Code (BGB), contractual liability in the case of donations is limited to intent and gross negligence as well as fraudulent concealing of defects. But if the donated food is then donated again, e.g., by a food bank, then the liability risks for the wholesaler/retailer may re-emerge. According to the letter of the law, the liability privilege in donation law applies only to the parties involved in the donation contract, i.e., the contract between the wholesaler/retailer and the food bank, and the contract between the food bank and the consumer, but not between the wholesaler/retailer and the consumer. Whether the limitation of liability also extends to the relationship between the wholesaler/retailer and the consumer is unresolved. In addition, the liability of the manufacturer in accordance with the Product Liability Act cannot be excluded (§ 14 ProdHG).[180] As a result, liability risks around food donations to food banks cannot be ruled out completely.[181]

[180] Cf. Voit, Workshop Lebensmittelverluste und Lebensmittelrecht, Leuphana Universität Lüneburg, 4 April 2014, Zivilrechtliche Probleme des Mindesthaltbarkeitsdatums, p. 17, available at http://www.leuphana.de/fileadmin/user_upload/Forschungseinrichtungen/professuren/energie-und-umweltrecht/Lebensmittel-Workshop/Voit_MHD_Lueneburg_4_4_14_revSH-2.pdf.

[181] The information was extracted from BMELV 2012d: p. 13 and a lecture by Prof. Voit at the workshop "Food waste and food law" on 4 April 2014 in the framework of the present project.

According to EU law, food banks are legally[182] considered to be businesses in the food industry and are thus subject to all the provisions of food law. I.e., food banks are subject to the documentation requirements for traceability of goods[183] and the obligation to produce proof of compliance with food hygiene standards. Food banks train their staff to observe hygiene standards.
In the event that foods cause damage to the health of end consumers (e.g., pieces of glass in applesauce or missing labeling of allergens), the manufacturer's product liability takes effect (§ 1 ProdHG). This liability cannot be excluded or limited.
Civil liability: Here, it is important to differentiate between contractual liability and tort liability. As a matter of principle, both types must be considered in cases of damage to health.
Since the food bank generally donates food to people in need, a donation contract comes into being (by implication). As a matter of principle, liability arises from this donation contract, but the liability privilege for donors limits this liability to intent and gross negligence (§ 521 BGB) as well as fraudulently concealed defects (§ 524 BGB).
In the case of tort liability (compensation requirement in accordance with § 823 BGB), the wholesaler/retailer is also liable as a matter of principle, and this is true both in cases of intent and in cases of negligence. I.e., if the wholesaler/retailer donates spoiled food to the food bank, which in turn donates the goods to a person in need, who then suffers damage to his/her health, then the wholesaler/retailer can in principle be held liable for compensation.

***Several proposed solutions exist for the civil liability problem discussed here:***

The liability privilege could be expanded to include the donating wholesaler/retailer even in the case of tort liability, provided that it is clearly recognizable to the end consumer that the food bank, for its part, received the food as a donation. This expansion of the donation contract between the food bank and the recipient to include the wholesaler/retailer would mean that the liability privilege would extend to the wholesaler/retailer.

There are, however, various pitfalls to this solution: Firstly, in the absence of concrete litigation, this interpretation of the law has not yet been confirmed by the courts. Secondly, this approach should prove difficult to implement in practice, since the food bank would have to make clear to the recipient of the food who donated each individual product to the food bank. Thirdly, in the event of a lawsuit in which the claim for compensation of a person in need was rejected, this would amount to a negative political signal.

Therefore, the establishment of a liability fund has been proposed. It could be either a state-supported fund, an insurance model (potentially with state-subsidized premiums), or a combined form[184]. Concrete reports or studies examining the advantages and disadvantages of the various models are not available to date.

---

182 Art. 3 No. 2 Regulation (EC) No. 178/2002: "'food business' means any undertaking, whether for profit or not and whether public or private, carrying out any of the activities related to any stage of production, processing and distribution of food"; cf. also Art. 5 Regulation (EC) No. 852/2004.

183 Art. 18 Regulation (EC) No. 178/2002.

184 The foundation "*Conterganstiftung für behinderte Menschen*" (Contergan Foundation for Disabled People) established by the *Conterganstiftungsgesetz* (Gesetz über die Conterganstiftung für behinderte Menschen (Conterganstiftungsgesetz, Law on the Contergan Foundation for Disabled People – ContStifG) in the version of its promulgation on 25 June 2009 (BGBl. I p. 1537), amended by Art. 1 of the law of 26 June 2012 (BGBl. I p. 1847), could serve as a reference. This foundation is financed by funds from a settlement between the parents of the children affected and the manufacturer as well

A third proposal refers to regulating the issue by means of a law. The Bill Emerson Good Samaritan Food Donation Act[185], adopted in the US in 1996, is mentioned as a model. In Europe, Italy[186] is the only country to have adopted a comparable system.[187]

The Good Samaritan Act releases both the original donor and the nonprofit organizations from liability (excepting cases of gross negligence).[188]

In contrast, the Italian law defines the food bank as an end consumer[189] and thus rules out any claims of the person in need vis-à-vis upstream parts of the food chain.[190]

### Possible state measure

State agencies as well as wholesalers and retailers can review the establishment of a compensation fund or a system of insurance in order to support the donation of properly examined food even after the best-before date, which is a desired goal.[191] This would function as an additional legal safeguard for food banks. The Sewage sludge compensation fund (*Klärschlamm-Entschädigungsfonds)* in accordance with § 11 Fertilizer Act (*Düngegesetz* )[192] in conjunction with the Ordinance on the sewage sludge compensation fund (*Klärschlamm-Entschädigungsfondsverordnung)*,[193] could serve as an example of such a fund.

### Challenges

**Substantive challenges**: In order to realize proper implementation and application of such a compensation fund, it appears necessary to determine what best practices are in terms of wholesalers/retailers inspecting the donated foods for edibility regardless of the best-before date and how compliance with such best practices can be documented. In addition, the question of best practice will also arise concerning food handling by food banks through to donation to recipients. To date, these areas

---

as budgetary funds from the federal government augmenting the endowment of the foundation by a factor of more than three.

185 Public Law 104-210 of 1 October 1996, 110 STAT. 3011. Available at http://www.gpo.gov/fdsys/pkg/PLAW-104publ210/pdf/PLAW-104publ210.pdf, last accessed: 24 April 2015.

186 Legge 25 giugno 2003, n.155: Disciplina della distribuzione dei prodotti alimentari a fini di solidarieta' sociale. Gazzetta Ufficiale N. 150 del 1 Luglio 2003.

187 Priefer et al. 2013, Planchenstainer 2013.

188 "(1) Liability of person or gleaner
A person or gleaner shall not be subject to civil or criminal liability arising from the nature, age, packaging, or condition of apparently wholesome food or an apparently fit grocery product that the person or gleaner donates in good faith to a nonprofit organization for ultimate distribution to needy individuals.
(2) Liability of nonprofit organization
A nonprofit organization shall not be subject to civil or criminal liability arising from the nature, age, packaging, or condition of apparently wholesome food or an apparently fit grocery product that the nonprofit organization received as a donation in good faith from a person or gleaner for ultimate distribution to needy individuals.
(3) Exception
Paragraphs (1) and (2) shall not apply to an injury to or death of an ultimate user or recipient of the food or grocery product that results from an act or omission of the person, gleaner, or nonprofit organization, as applicable, constituting gross negligence or intentional misconduct."

189 In contrast to the legal interpretation of the BMELV presented above under (1).

190 Planchenstainer 2013: pp. 16f.

191 Ibid.: p. 18.

192 *Düngegesetz* of 9 January 2009 (BGBl. I pp. 54, 136).

193 *Klärschlamm-Entschädigungsfondsverordnung* of 20 May 1998 (BGBl. I p. 1048).

have not been regulated much, and tend to be characterized by the very diverse circumstances on the ground.

**Regulatory challenges**: Payment from the compensation fund will have to be linked to the existence of clear chains of causation because of the necessity of clarity and legal certainty. The instrument must be the subject of intensive expert discussions considering the most diverse possible cases of claims. Since the measures discussed support food banks, a measure itself does not constitute an intervention in fundamental rights. Potentially charging fees to be paid into such a fund is to be considered a different case. Here, designing funds in line with the constitution must be granted great importance.[194]

**Administrative challenges**: Possible administrative time and effort can be estimated only against the background of a concrete model for implementing a compensation fund.

#### Possible less invasive alternatives

A fund or an insurance model are relatively less invasive measures. Other measures that are equally effective but less invasive are not apparent.

#### Conclusion

From the perspective of the authors, it is of high societal relevance for food banks' access to edible foods (e.g., from wholesalers'/retailers' excess quantities of food) to be as broad and unimpaired as possible. For this reason, the ways to reduce existing obstacles outlined in this starting point should be discussed in a dialogue between the stakeholders in question from wholesaling/retailing, food banks, as well as the political community and public administration.

## 4.7 The authors' recommendations for measures

As a result of the research for existing proposals for measures (cf. 4.5), stock-taking of available legal instruments and the assessment of their suitability for various approaches to preventing food waste (cf. 4.6.3), as well as an initial evaluation of the instruments involved in possible measures (cf. Chapter 4.6.4), the authors identified the following measures suitable for implementation in the framework of the German WPP and constituting a specific contribution from the "environmental side" to ongoing efforts to prevent food waste.

### 4.7.1 Measure I: Analyses of the existing situation and derivation of "best practices" for selected areas of the food sector

#### Goal of the measure

A documentation of “best practices” in terms of waste-preventing process management and handling practices should be prepared for selected areas of the food-manufacturing and food-processing sectors.

This type of “codification” of waste-preventing "best practices," which in addition includes typical practical reference values for the relevant waste rates or the like, constitutes a key point of reference

[194] Cf. on the concept of such a fund Schomerus 2013: p. 238.

both for possible regulatory interventions[195] and for cooperative efforts toward waste prevention involving both governmental and food-sector actors.[196] Thus, this measure also serves very directly to implement the general "waste prevention measures in businesses" recommended in the German WPP as well as the "concerted actions and agreements between public institutions and industry/trade" that are more specific to food.[197]

### Concretizing possible starting points

Potential forms of implementing a documentation of good management practice for waste prevention in selected sectors of the food-processing sector were already discussed in section 4.6.4.3 of this report.[198]

The questions as to the concrete form of such guidance documents for enforcement and the bodies which are to prepare them are currently under discussion in the framework of the ongoing implementation of the requirements of the Industrial Emissions Directive (IED).

At present, no relevant model documents are available[199], and the BAT reference document applying to parts of food-processing operations[200] is limited almost exclusively to descriptions of measures to reduce emissions to the air and water.

### Recommended measure

In the context of this measure, the authors of the present study recommend the development of reference documents on waste-preventing best practices specifically for selected areas of the food-processing sector. The information available to date on waste rates[201] suggests that they should focus especially on establishments involved in OHC.[202]

When formulating best practice, it is possible in some cases to draw on existing pilot projects (e.g., for cafeterias); in addition, relevant sector analyses are to be carried out[203] in order to develop core requirements and parameters on this basis that are robust and transferable, and thus verifiable.

In light of the existing pressure to act in the area of food waste prevention, if a robust set of information for fact-based planning of further measures is to be generated within a reasonable time frame, it appears sensible to coordinate implementation of these measures between the federal level and the *Länder*. This could mean that following such a process of coordination, the federal government and

---

195 For example, the formulation and application of requirements for enforcement in accordance with § 5 Para. 1 Sentence 1 No. 3 BImSchG as well as potentially necessary statutory instruments in accordance with § 22 BImSchG.

196 For example, the formulation and monitoring of substantial reduction goals and reduction measures.

197 For both, cf. German WPP, p. 30.

198 In particular model administrative regulations (MWvW) of the LAI come into question.

199 Although numerous VDI Standards (VDI = *Verband Deutscher Ingenieure*, The Association of German Engineers) for food-processing operations exist, their focus is exclusively on measures to reduce emissions.

200 Reference Document on Best Available Techniques in the Food, Drink and Milk Industries, current as of august 2006, cf. http://eippcb.jrc.ec.europa.eu/reference/BREF/fdm_bref_0806.pdf.

201 As has been frequently explained, the information available in the context of discussions about preventing food waste is not (yet) sufficient in terms of its degree of detail—in terms of both the amounts of waste and its composition for the different types of operations—for policy-makers to conclusively set priorities for such activities.

202 From the perspective of environmental relevance, in particular those sectors are important in which animal-based products, i.e., meat in particular, are processed.

203 The results available to date from individual studies of businesses used as examples should be called into question in terms of their broad transferability to other cases, both because of the relatively small numbers of businesses and because the businesses participating in the studies tended to be proactive pioneers.

various *Länder* would conduct relevant surveys, each in different sectors of the food industry, that could then be assembled to create an overarching analysis of the existing situation.[204]

Informative representations of good management practice and the relevant reference values developed on the basis of the analyses of the existing situation must be prepared; they should be differentiated in detail for the various types of operations, food processing processes, and forms of distributing and serving food. Active, cooperative collaboration with the market actors in the relevant sectors during this process is a reasonable approach.

### 4.7.2 Measure II: Initiation of a high-ranking roundtable on the prevention of food losses

#### Goal of the measure

Concerning food waste, the German WPP states very clearly on page 30: "*With a view to preventing food waste, concerted actions and agreements between public institutions and industry/trade are to be encouraged in order to minimize food waste occurring along the production and supply chain. The goal is to take the entire value-added chain into consideration in order to reduce wastage.*"

In fact, this is not an individual measure, but an entire package of measures that must support and strengthen each other in order to achieve a substantial reduction of the amounts of food waste overall.

Such a package of measures should include the following elements:

- Clear political definition of the desired overarching reduction goals and high-priority areas of action. At least the EU Commission's aspirational 30% reduction goal[205] should be defined as a binding national target by the responsible ministries and/or the federal government, and it should be made more concrete, as far as possible, by means of a clear benchmark and interim goals.
- Initiation of a roundtable on the prevention of food losses with high-ranking representatives at least from:
  - the ministries involved (consumer protection, environmental protection, and economic affairs) at the federal and the *Länder* levels,
  - food wholesalers and retailers (representatives of the large chains as well as regional businesses),
  - food manufacturers as well as
  - the food processing sector
- Cooperative support of the process (limited in terms of space and time) of determining the amounts and types of food wastes in the various subsectors of the food sector.[206]
- Joint formulation of differentiated subsector-related reduction goals and the corresponding reduction measures.

---

[204] Such an approach would be significantly more efficient overall than conducting studies over and over again that are not oriented toward generating substantially new information, as has been the case so far.

[205] This refers to the proposal for a 30% reduction goal in the Communication of the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions "Towards a circular economy: A zero waste programme for Europe" (COM/2014/0398 final) of 2 July 2014 (cf. the deliberations in section 4.2.1).

[206] According to the expert opinion of the authors of this study, systematic, government-initiated analyses of the existing situation as described above in Measure I are essential, and this is also true in the context of the cooperative approach of Measure II. The expert discourse on food waste prevention to date shows clearly that even within the bodies of industry trade associations, such differentiated information is not available, with a few exceptions.

- Establishment of a transparent and informative reporting and monitoring system to monitor the jointly formulated reduction strategy and to support external reporting.[207]

### Concretizing possible starting points

Naturally, no single concrete legal starting point exists for initiating and establishing such concerted actions. The stakeholders' express political will is more important here. Nonetheless, it is surely helpful to refer to concrete agreements and joint efforts.

Above and beyond the non-binding 30% goal from "Towards a circular economy: A zero waste programme for Europe," the still outstanding Communication on Sustainable Food by the EU Commission, which was originally scheduled for 2013 in the context of the European Retail Action Plan, might provide additional helpful information and "anchor points" for the necessary concretization of the reduction goals and focal areas in Germany.[208]

With regard to integrating the relevant ministries in a concerted action, the German WPP, adopted by the German government, is surely the suitable starting point. In addition, reference should be made here to the relevant decisions and proposals from Brussels.

The latter is also true with a view to involving the stakeholders from the business community. In particular for retailing, the Retail Agreement on Waste[209] and the European Retail Action Plan[210] provide very concrete starting points for national activities. It may also be helpful at this point to refer to the relevant and positive reference experiences of concerted cooperation between the state and the business community in the UK.[211]

### Recommended measure

The authors recommend tackling the outlined package of measures as soon as possible. To this end, agreement should be achieved at a high political level within and between ministries about the goals and focal areas of the reductions to be achieved (e.g., with reference to the relevant proposals of the EU COM) as well as about the beginning dialogue among stakeholders.

In advance of the actual beginning of the dialogue, one would have to explore whether key food-sector actors are prepared to participate in and actively support the process, including clarifying a goal for a "roundtable" on which consensus might be reached.[212]

---

207 For example, in the context of periodic reports on the implementation of the German WPP.

208 Cf. on this the deliberations in section 4.2.1.

209 http://www.eurocommerce.eu/media/54887/retail-agreement-on-waste-updatedjune2013.pdf, last accessed 23 April 2015.

210 COM(2013) 36 final (see footnote 105). On the substance of this Communication, cf. also the explanations in chapter 4.2.1.

211 Even if the initial situation pertaining to the Courtauld Commitment was surely quite different from that in Germany (cf. also section 4.5.4), the practice that has been established there in the meantime appears to be a good example of cooperation between business community actors and government agencies that benefits both sides.

212 Such a consensus should encompass at least the joint development and implementation of measures for effectively reducing the food waste occurring in Germany as well as agreement on a reporting system for documenting the reductions achieved.
The identification of robust facts about the existing situation as well as the establishment of a transparent and robust monitoring system for food waste occurrence would be necessary and more ambitious goals.

### 4.7.3 Measure III: Integration of waste prevention in food-hygiene enforcement practices

#### Goal of the measure

Conflicting goals may exist in areas where the implementation of protective and preventive food hygiene measures and efforts to waste as little edible food as possible overlap.[213]

In the context of this measure, efforts should be made to grant the aspect of waste prevention appropriate importance when making the required trade-offs in situations where the implementation of food-hygiene requirements provides scope for discretion.

#### Concretizing possible starting points

In the practice of food-establishment operations as well as governmental enforcement, best-practice guidelines provide orientation for concrete procedures when implementing food-hygiene requirements. Such guidelines are an important element in the concept underlying the European Regulation on the hygiene of foodstuffs[214]. According to that regulation, guidelines can be prepared, developed, and disseminated at the European[215] or the national level[216].

In practice, the majority of guidelines relevant to the various processes of food manufacturing and use are prepared or proposed by trade association bodies at the national level and then reviewed by the responsible bodies of the *Länder*[217] according to the "procedure for reviewing guidelines for good procedural practice" set forth in Section 5 of the General Administrative Regulation on Food Hygiene.[218]

The procedure does not provide for coordination across ministries. Coordination between the Federal *Länder* occurs within the framework of the *Länder* working group on consumer protection (LAV), in particular in the working group AFFL[219] for the area of meat and poultry meat hygiene as well as specific questions concerning products of animal origin as well as the working group ALB[220] for (other) foods, materials and articles, wine, and cosmetics. The responsibility for coordinating the entire procedure of coordination and review lies with the German Federation for Food Law and Food Science (BLL e.V.); the procedure includes consumer representatives and the specialized agencies Federal Office of Consumer Protection and Food Safety (BVL), the Federal Institute for Risk Assessment (BfR),

---

213 Such overlaps exist, for example, in areas where food that is even only potentially hygienically compromised must be discarded; or if food is no longer classified as edible after a certain period of time, e.g., at service counters.

214 Regulation (EC) No. 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs, OJ EU L 139 of 30 April 2004, p. 1.

215 (EC) No. 852/2004, Art. 9

216 (EC) No. 852/2004, Art. 8

217 Depending on the area for which the guidelines are applicable, different *Länder* are responsible for coordinating this review. These responsibilities are laid down in Appendix 5 to the AVV LmH. For example, Bavaria is responsible for coordination in the area of the food service industry, institutional food services, and fast food outlets.

218 General administrative regulation on the implementation of official monitoring of compliance with hygiene regulations for animal-based food and on the procedure for reviewing best procedural practice guidelines (AVV Lebensmittelhygiene – AVV LmH) of 9 November 2009, last amended by administrative regulation of 20 October 2014 (BAnz AT 07 November 2014 B2).

and the *Friedrich-Loeffler-Institut*—Federal Research Institute for Animal Health (FLI), which are actively involved[221].

In the guidelines, best-practice requirements and procedures have been formulated exclusively in terms of food-hygiene considerations (to date). Cross-ministry coordination would make it possible to review in which way waste prevention aspects could be reflected in such guidelines and thus be enforced concretely in terms of food law.

**Recommended measure**

The proposed measure consists of planning and implementing a common discussion and coordination process between experts from the area of the LAV, i.e., the AFFL, the ALB, and the ALS, as well as representatives of the federal and *Länder* environment ministries, where the opportunities and limits of integrating waste prevention aspects in the guidelines for good management practice are made a topic of discussion. Against the background that most of the guidelines are issued by the trade associations of the food industry, it appears sensible to include the BLL in such a working session as well.

Similarly to the best-practice guidelines, the guiding principles of the German Food Code (DLBK), which are based on the work of the German Food Code Commission (DLMBK), include requirements that are potential obstacles to waste prevention. For this reason, the authors of the present study believe that a review of individual guiding principles in terms of this aspect is advisable, following the relevant procedures of the DLMBK's rules of procedure and with the involvement of the Environment Ministry.

### 4.7.4 Measure IV: Support of food bank concepts by limiting liability risks when donating food to third parties

**Goal of the measure**

Food banks collect qualitatively unobjectionable food that wholesalers and retailers are unable to sell and give it to the needy. There are currently more than 900 food banks in Germany, most of which are not-for-profit organizations. Across Germany, they support more than 1.5 million people in need with food.[222]

For example, food donated by retailers is handed out by the food banks, usually free of charge. The best-before date of many of these food items has passed or is about to pass. If retailers carefully examine these food items and explicitly mention the issue to the food bank operators, this does not pose a legal problem. However, if spoiled food items are mistakenly donated to a food bank and then given to a person in need, causing this person to suffer damage to his/her health, the retailer's liability for damages cannot be generally ruled out. There is no case law yet in this matter.

According to representatives of wholesalers/retailers as well as food banks, it should be assumed that the remaining legal uncertainty means that some food items that could be given to food banks in fact are not. In light of the ecological and social win-win situation resulting from not-for-profit food banks being provided with food that is still edible, it seems desirable for society as a whole to remove, as far as possible, potential obstacles to wholesalers/retailers donating such food to food banks.

[222] cf. Bundesverband Deutsche Tafel e.V., http://www.tafel.de/.

**Concretizing possible starting points**

In this situation, the authors are of the opinion that it is reasonable to implement a countermeasure whose effect is not least psychological. The establishment of a compensation fund financed in equal measure by the state and wholesalers/retailers would surely be an effective means. A fairly low financial commitment—due to the surely low probability of occurrence of damages—could provide a clear signal of the joint responsibility of the government and the business community as well as of society's appreciation of food banks.

Amendments of laws and/or imaginable (financially supported) insurance models appear less appropriate at this time.

**Recommended measure**

The authors recommend that the willingness to create such a compensation fund should be explored in a dialogue between the relevant stakeholders, including wholesalers and retailers, food banks, the political community, and public administration, and that agreement is reached on key points for possible implementation. On this basis, a final version of the concrete concept of such a fund is to be elaborated in detail.

### 4.7.5 Measure V: Development of information modules on the environment-related significance of food wastes

**Goal of the measure**

A consistent assessment of the environmental impacts of the occurrence of food waste was prepared for the first time in this project. This shows, impressively and differentiated according to various impact categories and regional impact areas, the consequences of discarding food that has been produced in terms of the inputs that went into producing it.

This information as well as the evaluation of a number of case studies could be an important contribution by the Environment Ministry and environmental agencies to raising awareness on the part of consumers and market actors in terms of careful, waste-preventing handling of food.

**Concretizing possible starting points**

If the above-mentioned information is to reach a broad audience, it must be presented in easily comprehensible form and disseminated by means of appropriate information campaigns.

In light of the large number of ongoing efforts to provide information and raise awareness about food waste, the authors of this study do not consider it necessarily expedient for the Environment Ministry to launch a new, additional campaign. Even today, it can be observed that interested citizens tend to be confronted with information overload concerning this topic and the corresponding difficulties in finding expert orientation.

Against this background, it appears advisable to review whether the information generated can be integrated in a targeted fashion in ongoing information campaigns and other ways in which information is provided by agencies at the federal or *Länder* level. The evaluation of information campaigns in Appendix I provides helpful starting points in this regard.

**Recommended measure**

The recommended measure includes the following steps:

The responsible authorities within the Federal Environment Agency and the Federal Environment Ministry contact those responsible for providing information, including the ongoing information campaigns at the federal and *Länder* level and evaluate i) their willingness to include additional, environment-related facts and tips, and ii) which formal and design requirements are currently made of such information, as appropriate.

This feedback should form the basis upon which the environment-related information is then packaged in a simple and structured form suitable for dissemination in the framework of the campaigns willing to cooperate.

An alternative would be for the Federal Environment Agency to provide environment-related information on food waste prevention on websites of its own that are dedicated to the issue and to offer the interested operators of campaigns and information portals the opportunity to provide links to those websites.

### 4.7.6 Approaches to measures that were not taken up

Some approaches to measures that are to be found in secondary studies and are often discussed in the current expert discussions on the topic specifically from an environmental perspective, for example direct marketing concepts, producer-consumer networks, or urban gardening approaches, were not taken up by the authors. The reasons for this are provided briefly in the following.

The catchwords mentioned refer to a large number of very concrete and practical approaches, all of which basically aim to establish anew consumers' knowledge about and emotional connections to the conditions under which their food is produced, which have been lost due to the established industrialized mode of manufacturing and distributing food.

From an environmental perspective, but also in terms of health, these activities are of particular importance. After all, there is a broad consensus that only if consumers' appreciation of their food is enhanced (again) and they are thus willing to pay higher prices, this will create underlying conditions enabling broad implementation of environmentally more compatible and more diverse agricultural production of food.

Against this background, it first appears logical to use the current awareness of the topic of food waste to support such efforts. Yet the authors also believe that such a link of these issues also entails significant risks in the medium term.

For one thing, such risks lie in the field of communication: Sustainable appreciation cannot be created by moral pressure—yet waste prevention is perceived mostly as a moral-ethical necessity ("It is wrong to waste food!"). More promising approaches include aspects such as proximity to nature, variety of flavors, or simply "real" products etc.

For another, the following risks exist: There is no evidence that small-scale food distribution that is more closely linked and oriented to supplying the public at large with food entails smaller amounts of waste in the narrower sense. The discussions on the topic, which are often highly emotional, fail to recognize the fact that the current supply concept has a strong orientation toward efficiency, especially in distribution, and can certainly point to successes in this regard[223], while small-scale systems do not necessarily have the same opportunities due to a lack of economies of scale.[224]

---

[223] This by no means contradicts the real amounts of waste to be observed, because the question at this point is not: "are the amounts large?", but: "would they be relevantly lower with a different supply model?".

[224] The positive effects of direct supply lie less in lower storage or management losses and more in the lower loss rates "in the fields," in other words, in an area outside the more narrowly defined debate about waste.

That is why the authors believe that the environment ministries at the federal and *Länder* levels should definitely continue to support these concepts. However, directly coupling them with the waste prevention debate should be avoided.

The approach of including waste prevention in awarding public procurement contracts was not elaborated to the level of a recommended measure, either. It is true that the legal evaluation shows that the existing regulations are certainly suitable, e.g., to formulate requirements concerning the waste intensity of the services when awarding public contracts for catering, concessions for cafeterias, or the like (cf. the deliberations in section 4.6.4.3). However, to date there is a lack of criteria and inspection systems for waste-preventing implementation of such services which could be referenced when formulating requirements for awarding contracts and evaluating tenders. Against this background, the authors believe that formulating the requirements for good management practice in waste prevention in various areas should be granted priority (see recommended measure I). Especially if this also involves developing independent review or certification systems and/or practical, quantitative targets (indices for waste intensity or the like), a suitable frame of reference will emerge which can be referred to when awarding public contracts, taking the legal requirements into account.

# 5 Conclusions

From the perspective of the authors and on the basis of the results of the analyses conducted, the following conclusions should be drawn with regard to the prevention or reduction of food losses and wastes.

The assessments conducted concerning the environmental impacts of food consumption in Germany demonstrate clearly that the food losses entail serious climate impacts and additional resource use. In the numerical data of food losses available to date, especially the large amount of waste in away-from-home consumption is striking: roughly 1/3 of the food input here is not eaten in the end.

Food losses from animal-based products are associated with significantly greater environmental impacts than food losses from plant-based products and should therefore be granted priority with regard to prevention.

However, the models prepared in the project as a basis for the environmental assessment also made it clear that the data on food losses is unsatisfactory overall. In order to set priorities for reduction efforts rationally, based on environmental relevance, more far-reaching and robust information on the amount and type of losses would necessary, and within the various steps of the value-added chain, they would have to differentiate by various forms of operations and production chains. This is true in particular of food manufacturing, food processing, and OHC operations, but also of food wholesalers and retailers, for whom no data broken down by the type and amounts of wastes is available.

The legal analysis shows that German environmental law offers ways to effectively call for both generating an informative set of information on types and amounts of waste and implementing good management practice in the establishments involved in the food sector. With a view to possible less invasive measures, the authors of this study recommend the establishment of a roundtable with high-ranking members as well as other measures in order to implement the German WPP. In this context, it should be explored whether these two key aspects could also be implemented on a voluntary basis and still be sufficiently binding and informative. A reduction goal should be set as a point of reference for such activities; the goal should use the EU Commission's proposals for a 30% reduction of food losses as a point of orientation.

# 6 Bibliography

Alemanno, Alberto; Carreño, Ignacio (2012): "Fat taxes" in Europe. A Legal and Policy Analysis under EU and WTO Law, European Food and Feed Law Review, Issue: 2/2013, pp. 97-112. Available at http://www.gastronomiaycia.com/wp-content/uploads/2012/09/Impuesto_Grasa_Europa.pdf, last accessed 22 August 2014.

Begründung des Entwurfs für das Gesetz zur Straffung der Umweltstatistik, BT-Ds. Nr. 15/5538 of 26 May 2005, pp. 18.

BLE – Federal Office for Agriculture and Food (2012): Meldung zur Zahl der im Jahr 2011 nach der EU-Öko-VO 834/2007 kontrollierten Betriebe und der ökologisch bewirtschafteten Fläche. Bonn.

Blumenthal, A.; Göbel, C. (2014): Weniger ist mehr. In: gv-praxis 2/14: pp. 52f.

Body blow for butter-loving Danes as fat tax kicks in," in: The Guardian 2 October 2011. Available at http://www.theguardian.com/world/2011/oct/02/denmark-fat-tax-obesity, last accessed 22 August 2014.

Böhm, M.; Lingenfelder, M.; Voit, W. (2011): Verbraucherinformation auf dem Prüfstand. In: Neue Zeitschrift für Verwaltungsrecht, issue 4: pp. 198-201.

Bringewat, Jörn (2014): Mysterium § 12 BImSchG – Welche Ermächtigungsgrundlage erlaubt Änderungen an Nebenbestimmungen einer bestehenden immissionsschutzrechtlichen Genehmigung? In: jurOP of 29 July 2014. Available at http://www.jurop.org/baurecht/mysterium-%C2%A7-12-bimschg-welche-ermaechtigungsgrundlage-erlaubt-aenderungen-an-nebenbestimmungen-einer-bestehenden-immissionsschutzrechtlichen-genehmigung/, last accessed 15 April 2015.

Brohmann, B.; Fritsche, U.R.; Hartard, S.; Schmied, M.; Schmitt, B.; Schönfelder, C.; Schütt, N.; Roos, W.; Stahl, H.; Timpe, C.; Wiegmann, K. (2002): Nachhaltige Stadtteile auf innerstädtischen Konversionsflächen: Stoffstromanalyse als Bewertungsinstrument. Öko-Institut, Darmstadt/Freiburg. Available at http://www.oeko.de/service/cities/files/endbericht_%20final2002rev.pdf, last accessed 8 April 2015.

Centre for Strategy and Evaluation (2012): Evaluation of the Ecodesign Directive (2009/125/EC) – Final Report. Available at http://ec.europa.eu/enterprise/policies/sustainable-business/ecodesign/review/index_en.htm, last accessed 15 April 2015.

De Baan, L.; Alkemade, R.; Koellner, T. (2013): Land Use Impacts on Biodiversity in LCA: a global approach. In: The International Journal of Life Cycle Assessment. Vol. 18, Issue 6: pp. 1216-1230.

Dehoust, Günter; Jepsen, Dirk; Knappe, Florian; Wilts, Henning (2013): Inhaltliche Umsetzung von Art. 29 der Richtlinie 2008/98/EG. Wissenschaftlich-technische Grundlagen für ein bundesweites Abfallvermeidungsprogramm. UFOPLAN research code number: 371032310. Available at http://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/texte_38_2013_abfallvermeidungsprogramm_krause_bf_0_0.pdf, last accessed 08 April 2015.

Deutscher Fachverlag (ed.) (2011): Jahrbuch Außer-Haus-Markt 2010/2011. Verlagsgruppe Deutscher Fachverlag, Frankfurt.

Die deutschen Reismühlen: Zahlen und Fakten. Available at http://www.reismuehlen.de/index.php?id=12, last accessed 6 January 2013.

Eberle, U. et al. (2010): Für eine erneuerte Esskultur. Wie Essen und Trinken bei sinkendem materiellen Wohlstand zu mehr Wohlbefinden beitragen. Memorandum des Denkkreis Lebens-Mittel des Denkwerks Zukunft, Bonn. Available at http://r.search.yahoo.com/_ylt=A7x9UnBbQyVVaV8A41qz4lIQ;_ylu=X3oDMTBydWpobjZlBHNlYwNzcgRwb3MDMQRjb2xvA2lyMgR2dGlkAw--/RV=2/RE=1428534236/RO=10/RU=http%3a%2f%2fwww.denkwerkzukunft.de%2fdownloads%2fMemorandumLM-Mai2010.pdf/RK=0/RS=qsIu7bgFgYI.FarZMEGGtDqEhI8-, last accessed 8 April 2015.

Eberle, U.; Hayn, D. (2007): Ernährungswende. Eine Herausforderung für Politik, Unternehmen und Gesellschaft. Broschüre, Öko-Institut (ed.). Freiburg.

Eberle, U.; Hayn, D.; Rehaag, R.; Simshäuser, U. (eds.) (2006): Ernährungswende. Eine Herausforderung für Politik, Unternehmen und Gesellschaft. Ökom-Verlag, Munich.

European Commission (2009): Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - A better functioning food supply chain in Europe. COM

(2009) 591 final. Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0591:FIN:de:PDF, last accessed 27 October 2014.

European Commission (2006): Environmental Impact of Products (EIPRO). Analysis of the life cycle environmental impacts related to the final consumption of the EU-25. Main report. Available at http://ec.europa.eu/environment/ipp/pdf/eipro_report.pdf, last accessed 27 October 2014.

"Fat Tax has little effect." In: Politiken, 23 November 2011. Available at http://politiken.dk/newsinenglish/ECE1459080/fat-tax-has-little-effect/, last accessed 26 March 2014.

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) (2013): Abfallvermeidungsprogramm des Bundes unter Beteiligung der Länder. Available at http://www.bmub.bund.de/fileadmin/Daten_BMU/Pools/Broschueren/abfallvermeidungsprogramm_bf.pdf, last accessed 8 April 2015.

Federal Ministry of Food and Agriculture and Consumer Protection – BMELV (ed.) (2012a): Gesamtbericht: Einfuhr von Südfrüchten, Obst, Gemüse, Schalenfrüchten, Kartoffeln sowie Mostobst, KN 07/08. Available at http://berichte.bmelv-statistik.de/AHB-0033401-2012.pdf, last accessed 06 January 2013.

Federal Ministry of Food and Agriculture and Consumer Protection – BMELV (ed.) (2012b): Deutsche Einfuhr von lebendem Schlachtvieh in Schlachtgewicht (SG), Fleisch und Fleischerzeugnissen im Kalenderjahr 2012 (vorl. Ergebnisse). Available at http://berichte.bmelv-statistik.de/AHB-0033110-2012.pdf, last accessed 6 January 2013.

Federal Ministry of Food and Agriculture and Consumer Protection – BMELV (ed.) (2012c): Deutsche Einfuhr von Milch und Milcherzeugnissen 2011 – 2012. Available at http://berichte.bmelv-statistik.de/AHB-0033210-2012.pdf, last accessed 6 January 2013.

Federal Ministry of Food and Agriculture and Consumer Protection – BMELV (ed.) (2012d): Leitfaden für die Weitergabe von Lebensmitteln an soziale Einrichtungen: Rechtliche Aspekte. Available at http://www.etracker.com/lnkcnt.php?et=dQsrB9&url=http%3A%2F%2Fwww.bmel.de%2FSharedDocs%2FDownloads%2FBroschueren%2FLeifadenWeitergabeLMSozEinrichtungen.pdf%3Bjsessionid%3DF4E164A22FAA74FDDCD2FC65F4F7F1F1.2_cid376%3F__blob%3DpublicationFile&lnkname=Leitfaden-Tafeln, last accessed 8 April 2015.

Federal Ministry of Food and Agriculture and Consumer Protection (2012e): Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten der Bundesrepublik Deutschland. Federal Ministry of Food and Agriculture and Consumer Protection 2012. Available at http://berichte.bmelv-statistik.de/SJB-0002012-2012.pdf, last accessed 8 April 2015.

Federal Statistical Office (2010): Income and Expenditure Survey 2008. Wiesbaden.

Federal Statistical Office (2013): Öffentliche Wasserversorgung in Deutschland von 1991 bis 2010. www.destatis.de.

Federal Statistical Office (2014): Umwelt, Abfallentsorgung, Fachserie 19 Reihe 1. Available at https://www.destatis.de/DE/Publikationen/Thematisch/UmweltstatistischeErhebungen/Abfallwirtschaft/Abfallentsorgung2190100127004.pdf?__blob=publicationFile, last accessed 15 April 2015.

"Fettsteuer lässt Inflation steigen." In: Nordschleswiger, 11 November 2011: Available at http://www.nordschleswiger.dk/news.4460.aspx?newscatid=36&newsid=38403&h=Fettsteuer%20l%C3%A4sst%20Inflation%20steigen&h=$headingParam, last accessed 15 April 2015.

Fisch-Informationszentrum (FIZ) e.V. (2012): Daten und Fakten 2012. No longer available online (Daten und Fakten 2014 available at http://fischinfo.de/images/broschueren/pdf/FIZ_DF_2014.pdf, last accessed 21 April 2015).

Flamme, Sabine; Gallenkemper, Bernhard; Gellenbeck, Klaus; Rotter, Susanne; Kranert, Martin; Nelles, Michael; Quicker, Peter Georg (eds.) (2013): 13. Münsteraner Abfallwirtschaftstage. Münsteraner Schriften zur Abfallwirtschaft Vol. 15. Münster.

Fluck, Jürgen (1996): Kreislaufwirtschafts- und Abfallgesetz. KrW-/AbfG mit zugehörigen Verordnungen, TA Abfall, TA Siedlungsabfall, EG-AbfVerbrVO, AbfVerbrG, EG-AbfRRL, Verzeichnisse des Landes- und des EG-Abfallrechts ; Textsammlung mit Einführung und Begriffserläuterungen. Heidelberg.

Fritsche, U.R. et al. (2004): Stoffstromanalyse zur nachhaltigen energetischen Nutzung von Biomasse. Endbericht zum Verbundforschungsprojekt von Öko-Institut (Projektleitung) und den wissenschaftlichen Partnern FhI-UMSICHT, IE, IFEU, IZES,

TU Braunschweig und TU München unter Mitarbeit von Fichtner und TU Berlin, gefördert vom BMUB, Darmstadt. Available at http://www.oeko.de/oekodoc/236/2004-025-de.pdf, last accessed 08 April 2015.

Fritsche, U.R.; Eberle, U. (2007): Treibhausgasemissionen durch Erzeugung und Verarbeitung von Lebensmitteln. Unter Mitarbeit von Kirsten Wiegmann und Klaus Schmitt. Öko-Instituts-Arbeitspapier. Darmstadt/Hamburg. Available at http://www.oeko.de/oekodoc/328/2007-011-de.pdf, last accessed 09 April 2015.

Gade, Søren; Klarskov, Jens (2012): A tax everyone wants to see cut. In: Copenhagen Post, 04 October 2012 http://cphpost.dk/news/opinion-a-tax-everyone-wants-to-see-cut.2935.html, last accessed 26 March 2014.

German Advisory Council on the Environment (*Sachverständigenrat für Umweltfragen*) (2012): Environmental Report 2012. Responsibility in a finite world. Berlin: Erich Schmidt Verlag. Available at http://www.umweltrat.de/SharedDocs/Downloads/EN/01_Environmental_Reports/2012_06_Environmental_Report_Chapter_alle.html, last accessed 31 March 2014.

Göbel, Christine et al. (2012): Verringerung von Lebensmittelabfällen – Identifikation von Ursachen und Handlungsoptionen in Nordrhein-Westfalen (Reducing Food Waste – Identification of causes and courses of action in the German State of North Rhine-Westphalia). iSuN Fachhochschule Münster University of Applied Sciences. Available at https://www.fh-muenster.de/isun/downloads/Studie_Verringerung_von_Lebensmittelabfaellen.pdf, last accessed 8 April 2015.

Goedkoop, M.J.; Heijungs, R.; Huijbregts, M.; De Schryver, A.; Struijs, J.; Van Zelm, R. (2009): ReCiPe 2008, A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level; First edition Report I: Characterisation.

Gustavsson, Jenny; Cederberg, Christel; Sonesson, Ulf; van Otterdijk, Robert; Meybeck, Alexandre (2011): Global food losses and food waste. Extent, causes and prevention. FAO: Rome. Available at http://www.fao.org/docrep/014/mb060e/mb060e.pdf, last accessed 27 August 2014.

Gwozdz, Wencke (2011): Showcase: On the Way to a Fat Tax in Denmark. CORPUS – The SCP Knowledge Hub, Berlin. Available at http://www.scp-knowledge.eu/sites/default/files/knowledge/attachments/KU%20Showcase%20On%20the%20Way%20to%20a%20Fat%20Tax%20in%20Denmark.pdf, last accessed 22 August 2014.

Hafner, Gerold; Barabosz, Jakob; Kranert, Martin (2013): Ressourcenrelevanz von Lebensmittelabfällen. In: Flamme et al.: 13. Münsteraner Abfallwirtschaftstage. loc.cit.: pp. 101-107.

Hansmann, K. (1990): Inhalt und Reichweite der Reststoffvorschrift des § 5 Absatz I Nr. 3 BImSchG. In: Neue Zeitschrift für Verwaltungsrecht, issue 5: pp. 409-504.

Herrmann, Andreas (2012): Rechtsgutachten umweltfreundliche öffentliche Beschaffung, UBA Texte 35/2012. Available at http://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/4314.pdf, last accessed 15 April 2015.

Hünecke, K.; Fritsche, U.; Eberle, U. (2004): Lebenszykluskosten von Ernährung. Ernährungswende-Diskussionspapier Nr. 2. Darmstadt/Hamburg.

Jarass, Hans D. (2013): Bundes-Immissionsschutzgesetz: Kommentar unter Berücksichtigung der Bundes-Immissionsschutzverordnungen, der TA Luft sowie der TA Lärm, 10th edition. Munich.

Jensen, Jørgen Dejgård; Smed Sinne (2012): The Danish tax on saturated fat: Short run effects on consumption and consumer prices of fats. FOI Working Paper 2012/4, University of Copenhagen: Institute of Food and Resource Economics. Available at http://okonomi.foi.dk/workingpapers/WPpdf/WP2012/WP_2012_14_Danish_fat_tax.pdf, last accessed 26 March 2014.

Kastner, T.; Ibarrola Rivas, M.J.; Koch, W.; Nonhebel, S. (2012): Global changes in diets and the consequences for land requirements for food, PNAS 18/2012, pp. 6868-6872

Keller, M. (2010): Flugimporte von Lebensmitteln und Blumen nach Deutschland. Eine Untersuchung im Auftrag der Verbraucherzentralen, Gießen. Available at http://www.vzhh.de/docs/100187/Studie%20Flugimporte_Deutschland%202010.pdf, last accessed 09 April 2015.

Knappe, Florian; Reinhardt, Joachim; Diebel, Anton (2013): Ideen für mögliche Maßnahmen zur Abfallvermeidung in Baden-Württemberg. LUBW Karlsruhe. Available at http://www.lubw.baden-wuerttemberg.de/servlet/is/227391/, last accessed 25 August 2014.

KErn – Kompetenzzentrum für Ernährung an der Bayerischen Landesanstalt für Landwirtschaft (2014): Lebensmittelverluste und Wegwerfraten im Freistaat Bayern, Kulmbach. Summary available at http://www.kern.bayern.de/mam/cms03/wissenstransfer/dateien/lebensmittelverluste-bayern-2014.pdf, last accessed 09 April 2015.

Knieriemen, Heinz (2002): Lexikon Gentechnik, Fooddesign, Ernährung. Aarau.

Kranert, M.; Hafner, G.; Barabosz, J.; Schuller, H.; Leverenz, D.; Kölbig, A.; Schneider, F.; Lebersorger, S.; Scherhaufer, S. (2012): Ermittlung der weggeworfenen Lebensmittelmengen und Vorschläge zur Verminderung der Wegwerfrate bei Lebensmitteln in Deutschland. (Determination of discarded food and proposals for a minimization of food wastage in Germany) University Stuttgart, Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA) Available at http://www.bmel.de/SharedDocs/Downloads/Ernaehrung/WvL/Studie_Lebensmittelabfaelle_Langfassung.pdf?__blob=publicationFile, last accessed 25 August 2014. Abridged version in English available at http://www.bmel.de/SharedDocs/Downloads/EN/Food/Studie_Lebensmittelabfaelle_Kurzfassung.pdf?__blob=publicationFile.

Landmann, Robert; Rohmer, Gustav (2013): Umweltrecht, 70. Ergänzungslieferung.

Landwirtschaftliches Technologiezentrum Augustenberg (2014): Pflanzenproduktion 2014, Pflanzenschutz im Gemüsebau, Karlsruhe.

Leicester, Andrew; Windmeijer, Frank (2004) The "fat tax": economic incentives to reduce obesity. (IFS Briefing Notes BN49 ). Institute for Fiscal Studies: London, UK. Available at http://discovery.ucl.ac.uk/14931/1/14931.pdf, last accessed 22 August 2014.

Lipinski, Brain; Hanson, Craig; Lomax, James; Kitinoja, Lisa; Waite, Richard; Searchinger, Tim (2013): Reducing Food Loss and Waste. Working Paper, Installment 2 of Creating a Sustainable Food Future. Washington, DC: World Resources Institute. Available at http://www.wri.org/publication/creating-sustainable-food-future-installment-two, last accessed 23 April 2014.

Lov om afgift af mættet fedt i visse fødevarer (Fedtafgiftsloven), OV nr 247 af 30/03/2011 Gæld ende, of 31 March 2011. Available at https://www.retsinformation.dk/Forms/R0710.aspx?id=136314#Not1, last accessed 22 August 2014.

Lundie, S., Dennien, G., Morain M, Jones, M. (2007): Generation of an Industry-Specific Physico-Chemical Allocation Matrix. Application in the Dairy Industry and Implications for Systems Analysis (9 Pp). The International Journal of Life Cycle Assessment 12 (2): 109–17.

Marthinsen, Jarle; Sundt, Peter; Kaysen, Ole; Kirkevaag, Kathrine (2012): Prevention of food waste in restaurants, hotels, canteens and catering. Nordic Council of Ministers (ed.), Copenhagen. Available at http://www.norden.org/en/publications/publikationer/2012-537, last accessed 28 August 2014.

Meier, T. (2014): Umweltschutz mit Messer und Gabel. Der ökologische Rucksack der Ernährung in Deutschland. oekom, München.

Mekkonen, M.M. and Hökstra, A.Y. (2010): The green, blue and grey water footprint of crops and derived crop products, Value of Water Research Report Series No. 47, UNESCO-IHE, Delft, the Netherlands.

Meyer, Alfred Hagen; Streinz, Rudolf (eds.) (2012): LFGB, BasisVO, HCVO. Lebensmittel- und Futtermittelgesetzbuch, Basis-Verordnung (EG) Nr. 178/2002, Health Claim VO 1924/2006. Kommentar. Munich, 2nd edition.

Monier, V.; Midgal, S.; Escalon, V.; O'Connor, C.; Gibon, T.; Anderson, G.; Montoux, H.; Reisinger, H.; Dolley, P.; Ogilvie, S.; Morton, G. (2010): Preparatory Study on Food Waste in the EU 27. Final Report. BioS/ UBA/ AEA. Published by the European Commission. Available at http://ec.europa.eu/environment/archives/eussd/pdf/bio_foodwaste_report.pdf, last accessed 15 April 2015.

Mytton, Oliver; Clarke, Dushy; Rayner, Mike (2012): Taxing unhealthy food and drink to improve health. In: BMJ; 344: e2931. Available at http://www.bmj.com/content/344/bmj.e2931, last accessed 15 April 2015.

Nestle, Marion (2012): Fighting the flab means fighting makers of fatty food. In: New Scientist, 26 November. Available at http://www.newscientist.com/article/mg21628925.600-fighting-the-flab-means-fighting-makers-of-fatty-foods.html, last accessed 26 March 2014.

Ochs, Annette (2013): Speiseresteentsorgung in Deutschland. In: Flamme et al.: 13. Münsteraner Abfallwirtschaftstage. loc. cit. pp. 95-100.

Pelka, M.; Kreyenschmidt, J. (2013): Ermittlung des Verderbs von frischem Obst und Gemüse in Abhängigkeit von der Verpackungsart. Dortmund/Bonn. Available at www.stiftung-mehrweg.de.

Peter, G.; Kuhnert, H.; Haß, M.; Banse, M.; Roser, S.; Trierweiler, B.; Adler, C. (2013): Einschätzung der pflanzlichen Lebensmittelverluste im Bereich der landwirtschaftlichen Urproduktion. Johann Heinrich von Thünen-Institut, Max Rubner-Institut, Julius Kühn-Institut. Available at http://www.bmel.de/SharedDocs/Downloads/Ernaehrung/WvL/Studie_Lebensmittelverluste_Landwirtschaft.pdf?__blob=publicationFile, last accessed 8 April 2015.

Petersen, Frank; Doumet, Jean; Stöhr, Günter (2012): Das neue Kreislaufwirtschaftsgesetz. In: Neue Zeitschrift für Verwaltungsrecht, vol. 31, 9: pp. 512-530.

Pfister, S.; Koehler, A.; Hellweg, S. (2009): Assessing the environmental impacts of freshwater consumption in LCA. Environmental Science and Technology, 43 (11): pp. 4098-4104.

Planchenstainer, Francesco (2013): They collected what was left of the scraps: Food surplus as an opportunity and its legal incentives. In: The Trento Law and Technology Research Group, Research Paper No 13, University of Trento, Italy, February 2013. Available at http://eprints.biblio.unitn.it/4094/1/Trento_Lawtech_Research_Paper_13.pdf, last accessed 20 October 2014.

Ponton, Annette; Ludwig, Sebastian (2013): Internetgestütztes Abfall-Monitoring von Haushalten, Schwerpunkt Lebensmittelabfälle. In: Flamme et al.: 13. Münsteraner Abfallwirtschaftstage. loc.cit. pp. 108-112.

Prelle, Rebecca (2010): Abfallrechtliche Produktverantwortung – Rechtliche Zielsetzungen und Auswirkungen in der Praxis am Beispiel der AltfahrzeugV und des ElektroG. In: Zeitschrift für Umweltfragen, issue 11: 512.

Schmehl, Arndt (ed.) (2013): Gemeinschaftskommentar zum Kreislaufwirtschaftsgesetz (GK-KrWG). Cologne.

Priefer, C.; Jörissen, J. (2012): Frisch auf den Müll. Verringerung der Lebensmittelverluste als Ansatz zur Verbesserung der Welternährungssituation. Karlsruhe: ITAS Pre-Print: 22 November 2012. (published in: Decker, M.; Fleischer, T.; Schippl, J.; Weinberger, N. (eds.): Zukünftige Themen der Innovations- und Technikanalyse. Lessons Learned und ausgewählte Ergebnisse. KIT Scientific Reports 7668. Karlsruhe: KIT Scientific Publishing 2014, pp. 13-62) Available http://www.itas.kit.edu/pub/v/2014/epp/prjo12-pre01.pdf; last accessed 9 April 2015.

Priefer, C.; Jörissen, J.; Bräutigam, K.-R. (2013): Technology options for feeding 10 billion people -Options for Cutting Food Waste. Institute for Technology Assessment and Systems Analysis (ITAS). Karlsruhe. Available at http://www.europarl.europa.eu/RegData/etudes/etudes/join/2013/513515/IPOL-JOIN_ET%282013%29513515_EN.pdf, last accessed 8 April 2015.

Rosenbauer, J. (2011): Das Wegwerfen von Lebensmitteln – Einstellungen und Verhaltensmuster. Quantitative Studie in deutschen Privathaushalten. Ergebnisse Deutschland (im Auftrag von Cofresco Frischhalteprodukte Europa).

### Schäfer, F. (2014): Carbon Footprint ausgesuchter gartenbaulicher Kulturen im Rahmen eines Pilotprojektes zur neuen PAS 2050-1 - Bewertung der Treibhausgasemissionen entlang der Wertschöpfungskette. Institut für Nutzpflanzenwissenschaften und Ressourcenschutz, Bonn. Available at http://hss.ulb.uni-bonn.de/2014/3548/3548.pdf, last accessed 9 April 2015.

Schomerus, Thomas; Spengler, Laura (2010): Die Erweiterung der Ökodesign-Richtlinie – auf dem Weg zur „Super-Umweltrichtlinie?“ In: Zeitschrift für Europäisches Umwelt und Planungsrecht 2: 54-61.

Schomerus, Thomas; Tolkmitt, Ulrike (2007): Informationsfreiheit durch Zugangsvielfalt? Ein Vergleich der Informationszugangsrechte nach IFG, UIG und VIG. In: Zeitschrift für Öffentliches Recht und Verwaltungswissenschaft: 985.

Schomerus, Thomas (2013): Ein nationaler Energieeffizienzfonds – Instrument zur Umsetzung von Art. 7 der Energieeffizienz-Richtlinie 2012/27/EU?. In: Energierecht, vol. 2/6. Available at http://www.leuphana.de/fileadmin/user_upload/PERSONALPAGES/Fakultaet_2/Schomerus_Thomas/files/ZER_2013-06_Schomerus.pdf, last accessed 20 April 2015.

Schrader, Christian (1997): Produktverantwortung, Ordnungsrecht und Selbstverpflichtungen am Beispiel der Altautoentsorgung, In: Neue Zeitschrift für Verwaltungsrecht: pp. 943 - 949.

Snowdon, Christopher (2013): The Proof of the Pudding. Denmark's fat tax fiasco. IEA Current Controversies Paper No. 42, May 2013. Available at http://www.iea.org.uk/sites/default/files/publications/files/The%20Proof%20of%20the%20Pudding.pdf, last accessed 15 April 2015.

Stenmarck, Åsa; Hanssen, Ole Jörgen; Silvennoinen, Kirsi; Katajajuuri Juha-Matti; Werge, Mads (2011): Initiatives on prevention of food waste in the retail and wholesale trades. Nordic Council of Ministers (ed.), Copenhagen. Available at http://www.norden.org/en/publications/publikationer/2011-548, last accessed 28 August 2014.

Stuart, Tristram (2009): Waste. Uncovering the global food scandal. New York (et al.)

Stummerer, Sonja; Hablesreiter, Martin (2010): Food Design XL. Vienna.

Teitscheid, Petra (2013): Ursachen für Lebensmittelabfälle anhand ausgewählter Fallbeispiele. In: Flamme et al.: 13. Münsteraner Abfallwirtschaftstage. loc.cit. pp. 89-94.

Versteyl, Ludger-Anselm; Mann, Thomas; Schomerus, Thomas (2012): Kreislaufwirtschaftsgesetz: KrWG. Kommentar. 3rd edition. Munich.

UK could introduce "fat tax," says David Cameron, The Guardian 4 October 2011. Available at http://www.theguardian.com/politics/2011/oct/04/uk-obesity-tax-david-cameron, last accessed 22 August 2014.

UNEP (2012): Avoiding Future Famines: Strengthening the Ecological Foundation of Food Security through Sustainable Food Systems. United Nations Environment Programme (UNEP), Nairobi, Kenya. Available at http://www.unep.org/science/chiefscientist/Activities/EcosystemsManagementandAgricultureEfficiency/FoodSecurity.aspx, last accessed 27 August 2014.

Waarts, Yuca; Eppink, Mieke; Oosterkamp, Elsje; Hiller, Sabine; van der Sluis, Addie; Timmerman, Toine (2011): Reducing food waste. Obstacles experienced in legislation and regulations. LEI report 2011-059. Wageningen. Available at http://edepot.wur.nl/188798, last accessed 15 April 2015.

Wiegmann, K.; Eberle, U.; Fritsche, U.R.; Hünecke, K. (2005a): Umweltauswirkungen von Ernährung. Stoffstromanalysen und Szenarien. Ernährungswende-Diskussionspapier Nr. 7, Darmstadt/Hamburg, available at www.ernaehrungswende.de.

Wiegmann, K.; Eberle, U.; Fritsche, U.R.; Hünecke, K. (2005b): Datendokumentation zum Diskussionspapier Nr. 7 „Umweltauswirkungen von Ernährung – Stoffstromanalysen und Szenarien", Darmstadt/Hamburg, available at www.ernaehrungswende.de