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Determination of discarded food and proposals for a minimization of food wastage in Germany

- Abridged Version -

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Project partner: University of Natural Resources and Life Sciences (BOKU), Institute for Waste Management

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1 Introduction

1.1 Background

The Food and Agriculture Organization of the United Nations (FAO) assumes that roughly one-third of the food produced globally for human consumption, or about 1.3 billion tonnes per year, is lost or wasted. At the same time, around 925 million people are suffering from hunger and malnutrition according to the FAO.

Throughout the value-added chain of foods (production, processing, transport, trade, and disposal), we draw upon natural resources and consume considerable amounts of them. These natural resources are wasted if food that has already been produced ends up not being consumed. This results in negative impacts on the environment (e.g. land use, eutrophication, adverse effects on biodiversity, CO_2 emissions, etc.).

In addition, it is both ethically and socially unacceptable not to make use of food. This widens the gap even further between prosperity and poverty, affluence and malnutrition and industrialised and developing countries. Besides these social and ethical aspects, the costs to society and to the individual stakeholders should also be pointed out.

In Germany, too, the issue of food waste received a great deal of attention last year. Studies, press reports, radio and TV broadcasts on this subject were released on a regular basis and engaged socio-political attention. A wide audience gained an insight into the subject of food waste thanks to public events (e.g. podium debates, fairs) and the coverage surrounding the movie “Taste the waste.”

The Federal Consumer Protection Ministry also raised the issue of reducing food waste by launching the campaign "Each meal (time) is precious" with a view to enhancing the appreciation of food. Early 2012, the European Commission also put the subject on the policy agenda and set the goal of curbing the amount of needless food waste by 50 percent EU-wide.

This goal is an ambitious one and can only be achieved if reliable data on the quantities of food waste generated are collected beforehand throughout Europe. Up until now, these data have not yet been available for Germany. Neither has there been any systematic overview of measures, initiatives and expert discussions to date that might point out ways of reducing food waste from farm to fork. Decision-makers therefore lacked a scientifically substantiated basis on effective action to minimise food waste.

1.2 Goals and terms of reference

The project was aimed at estimating the quantities of food waste generated in Germany on the basis of statistics, research, literature, surveys, expert consultations and specific studies on a random basis. Beyond that, proposals on how to reduce the amount of discarded food were developed. In doing so, the research team differentiated by food industry, wholesale and retail trade and consumers (large-scale consumers and households). An estimation of food waste in the farming sector involves a great deal of effort. It is investigated in separated studies and was therefore not covered in this research project.

The project comprises research into the data currently available and expert discussions, with an extensive analysis of data and literature on quantities, measures and initiatives and expert discussions in other EU countries and industrialised nations (e.g. USA, Australia). On the basis of the researched database, the research team estimated the amount of food waste in Germany, formulated recommendations for preventive measures, whilst at the same time identifying existing data gaps and outlining proposals for their removal.

The researched measures and initiatives with regard to optimised food management were assessed, bearing utility aspects in mind. Aspects of efficiency and transferability to the environment prevailing in Germany played an important role in the assessment.

As a result, feasible best practice examples are identified which, if transferred to Germany, may be expected to exert positive effects on food management and, in particular, on the avoidance of food waste.

1.3 Definitions and delineation of the field of investigation

The stakeholders in the food value-added chain surveyed by the project are listed in the following (see Figure 1):

- Food industry
- Trade (wholesale and retail trade)
- Large-scale consumers (restaurant and catering sector, large-scale kitchen in hospitals, the armed forces etc.)
- Private consumers, households

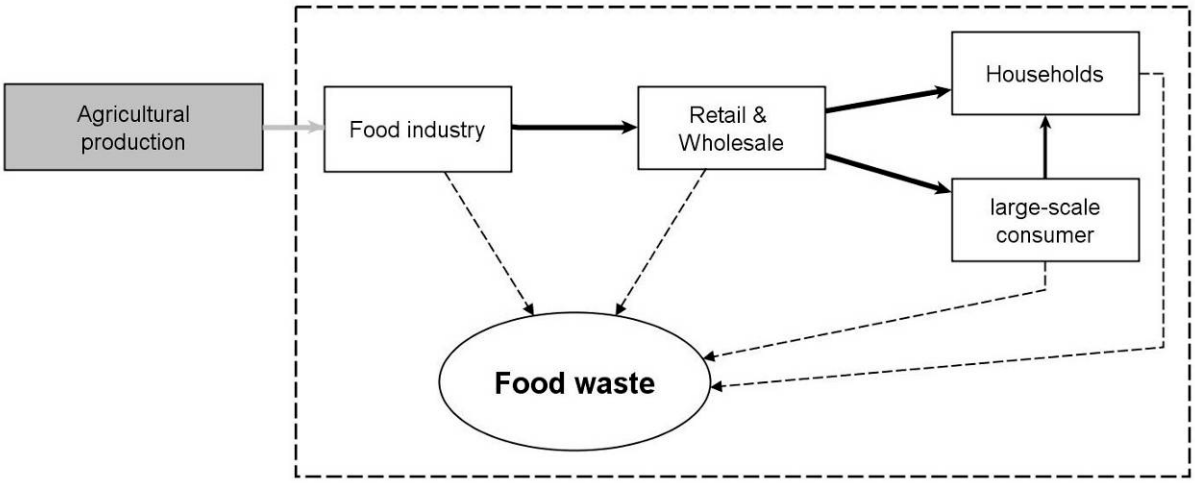

Figure 1: Areas of the value-added chain for food under examination

Definition: food waste

The term food waste comprises

- leftover food from
  - o agricultural production,
  - o (further) processing of food,
  - o wholesale and retail trade,
  - o kitchens of large-scale consumers,
  - o private households and
- raw and processed foods that are fit for consumption.

Food waste is further subdivided into

- Avoidable food waste: still fully fit for human consumption at the time of discarding or would have been edible if they had been eaten in time
- Partly (optional) avoidable food waste: generated because of different consumer habits (e.g. bread crusts, apple skins). This category also covers mixtures of avoidable and unavoidable waste (e.g. leftover food, canteen waste, etc.)
- Unavoidable food waste: usually arises when food is being prepared and is discarded. This mainly encompasses both non-edible constituents (e.g. bones, banana peels or the like) and edible ones (e.g. potato peels)

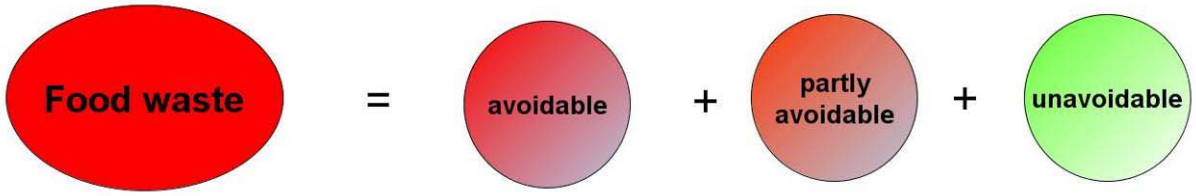

Figure 2: Breakdown of food waste by avoidability

2 Determining the quantities of discarded food in Germany

2.1 Existing studies

The following studies, for instance, are available for Germany:

- Preparatory study on food waste across EU 27 (Monier, et al., 2010)
- Throwing away food – attitudes and behavioural patterns (Cofresco Frischhalteprodukte Europa, 2011)
- Food losses in retail trade (EHI Retail Institute GmbH, 2011)
- Curbing food wastage – identification of causes and options for action in North Rhine-Westphalia (Teitscheid, et al., 2012)
- Generation, treatment and recycling of leftover food in Germany and the EU (Kohl, 2006)
- Costs and benefits of optimised biowaste recycling with a view to energy efficiency, climate change mitigation and resource conservation (Kern, et al., 2009)
- Flows of food waste as a matter for the waste disposal industry – problems arising in quantity determination (Wille, et al., 2002)
- Consumption patterns and generation of food waste in model households (Barabosz, 2011)

In addition, there are some other studies that deal with sub-sectors of the value-added chain of food.

In addition to the above studies for Germany, relevant studies from abroad were analysed and evaluated in order to broaden the database on food waste (cf. long version). Here, the following studies are mentioned by way of example:

- Global Food Losses and Food Waste (Gustavsson, et al., 2011)
- The food we waste (WRAP, 2008)
- Waste arising in the supply of food and drink to households in the UK (WRAP, 2010)

2.2 Methods to estimate the amount of discarded food in Germany

2.2.1 Food industry

To start with, existing studies and statistics were analysed for the investigation into the food industry. In the absence of sufficient usable data on food waste produced by the industry, a questionnaire was drawn up to determine the quantity of waste in consultation with the Federation of German Food and Drink Industries (*Bundesvereinigung der Deutschen Ernährungsindustrie (BVE*)). The questionnaire was distributed by the BVE and affiliated trade associations.

In addition, a revised questionnaire was distributed directly to most food business operators. Feedback as regards content and additions made by individual enterprises were incorporated in the revision.

2.2.2 Retail & Wholesale

At first, existing literature on trade (national and international studies, statistics, etc.) was analysed. These results were transferred to Germany with due regard to the methods used in each case.

In order to verify the database generated, trade associations for retail trade and for wholesale markets and other relevant stakeholders (e.g. food waste disposal firms) were contacted. Knowledge gained from these expert consultations and complementary on-the-spot checks were taken into account.

2.2.3 Large-scale consumers

The triangulation method was used for the analysis of large-scale consumers. Triangulation refers to a combination of more than one approach to produce results (cf. Blaikie, 1991). Thus, several calculation approaches were developed for the individual types of management of large-scale consumers as part of this research project to ensure best possible estimations of the amounts of food waste. In addition to the calculation regarding individual types of management, the total amount for all large-scale consumers was also

estimated. The results were then compared.

The calculation routes and data sources that were used for the individual types of management can be found in the long version of the research project. The results for the individual types of management were compared with the total estimation for large-scale consumers.

2.2.4 Private households

The following framework conditions must be taken into consideration when estimating/projecting the amount of food waste from private households: There are different ways to dispose of food waste (cf. Figure 3) of which the municipal waste collection system covers only a part. Like the amount of waste in general, the amount of food waste is subject to several influential factors (time, area studied, household type and size, time budget, income situation, personal lifestyle). This means that in reality there is no such thing as a typical average household that can serve as a statistical reference.

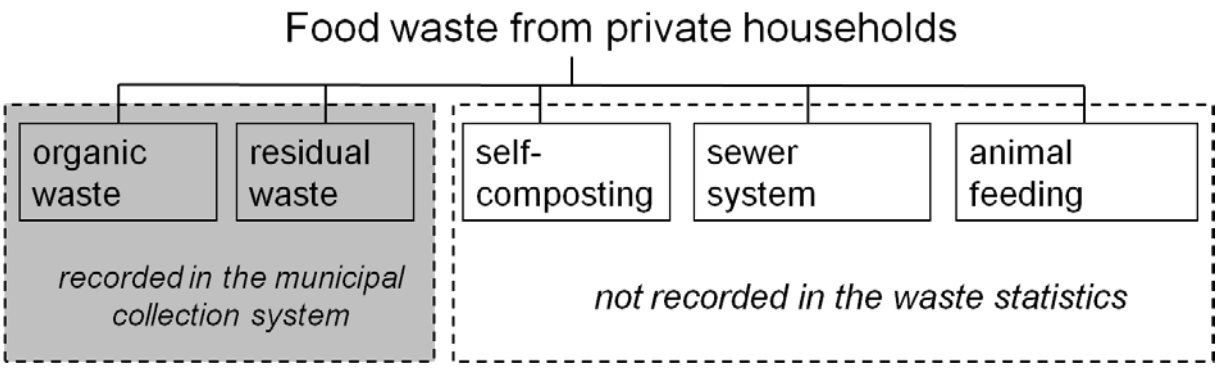

Figure 3: Disposal routes of household food waste

Projection approach:

- Critical evaluation of existing estimations for Germany. It has been found that the available data cover only parts of total food waste (e.g. no beverages, only food waste in the municipal collection system, only avoidable food, etc.).
- The amount of food waste was therefore extrapolated on the basis of data from waste collection analyses in Germany and from comparable national and international studies. The data were prepared and compiled (in comparable form wherever possible). The

extrapolation was based on waste data (amounts and composition of waste) and was complemented by transferring data from supply side studies or from other regions wherever this was necessary due to a lack of data availability:

- Estimation of the amount of food waste
  - in residual waste
  - in organic waste containers
  - in other disposal routes (self-composting, feeding to animals, sewer system).
- Estimation of the composition of food waste
  - by avoidability
  - by product groups
  - estimation of the monetary value of (avoidable) food waste

2.3 Results of the projections

2.3.1 Overview

Figure 4 shows the fluctuation margins of estimated food waste in Germany broken down by the areas of the food value-added chain that were analysed.

If one simplistically adds the mean values of these fluctuation margins, the total amount is 10,970,000 tonnes of food per year (cf. Figure 5).

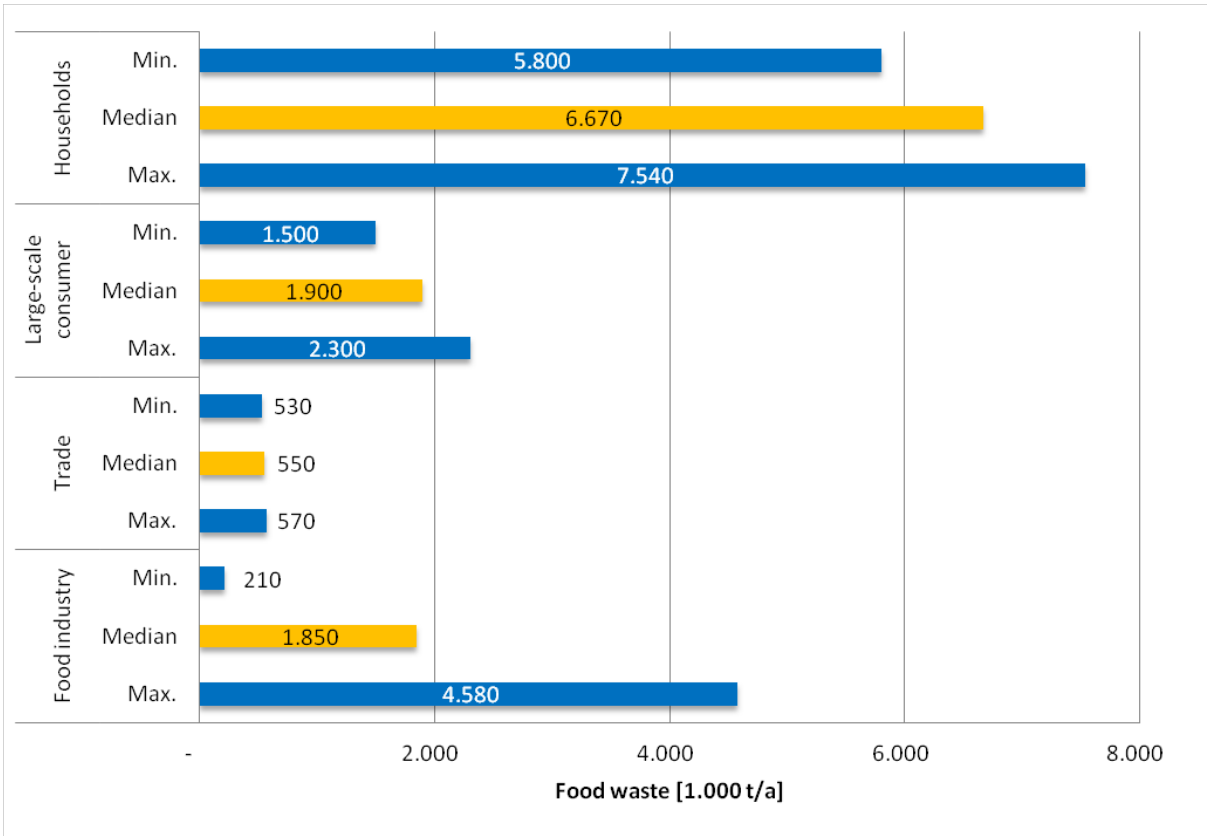

Figure 4: Range of food waste in Germany by areas of the food value-added chain

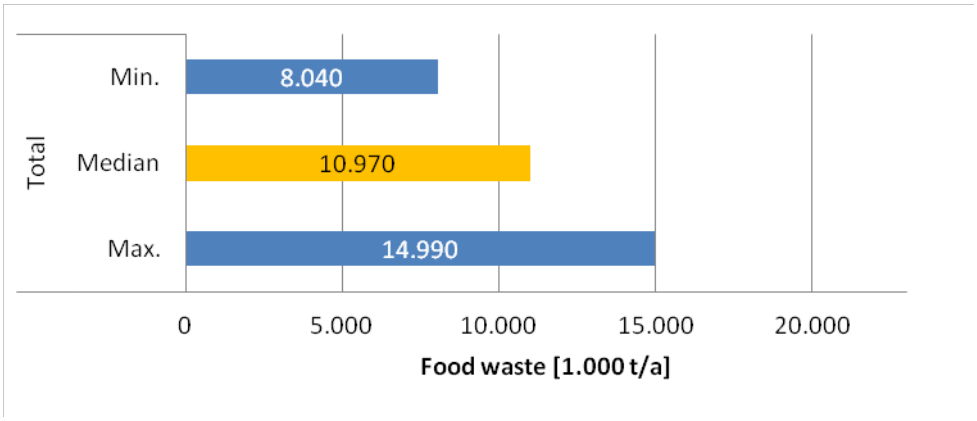

Figure 5: Range of total food waste in Germany

The percentage distribution of the calculated total amount is shown in Figure 6. One can see that of the analysed groups, households account for approximately two thirds of the amount of waste. The food industry and large-scale consumers each have a share of 17 percent. Compared with the other analysed groups, food waste from the trade sector accounts for only a small share of the total amount of waste. One must keep in mind that large parts of this amount are given to charities (cf. 2.2.2).

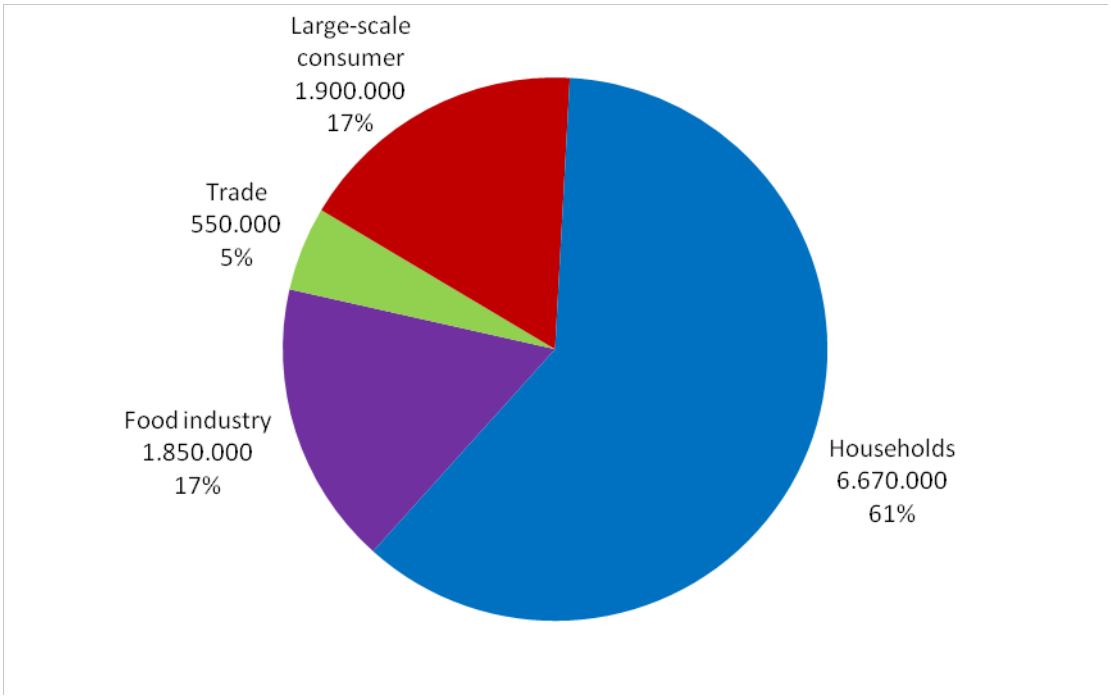

Figure 6: Distribution of food waste by value chain sectors for food (median) [t/a]

2.3.2 Food industry

By projecting and transferring the results from international studies the following fluctuation margin of the amounts of food waste from the industry emerges: 210,000 – 4,580,000 tonnes per year. The median value of this projection is 1,850,000 tonnes per year.

The fluctuation margin for industrial food waste is very large. This is due to the fact that the data basis is very unclear and that the industry has no clear definition of food waste. For instance, food waste given to third parties for utilization or fed to animals is not considered waste in some studies while it is included as such in others.

Some questionnaires were sent to trade associations and to food industry enterprises to be able to quantify the amounts mentioned above. Due to the low response rate it is impossible to calculate quantitative results.

From the available data material, however, qualitative findings can be deduced. Most enterprises surveyed stated that good and far-sighted operational planning should counter

avoidable food waste caused by overproduction and bad planning. Yet, it is nearly impossible to avoid food waste at this stage of the value-added chain. The demand for food is not always constant. Also, retained samples are stored for quality assurance. Their purpose is primarily to guarantee flawless and safe condition of products at least until their best-before date. These foods are then disposed of. Production losses and faulty batches caused by technical problems constitute an additional source of waste.

2.3.3 Retail & Wholesale

Projecting and transferring the results from international studies also yields major fluctuation margins in the trade sector: 460,000 – 4,790,000 tonnes per year. The median value of this projection is 750,000 tonnes per year and exhibits the largest deviation to the fluctuation margin compared with other sectors. Thus the maximum value is more than five times higher than the median value, which suggests that these are outliers. The reason is a total loss of ten percent in American trade, which serves as the basis of this value. Other European studies and conversations with relevant stakeholders do not confirm such high loss rates for the German trade sector.

In addition to the calculations, it was intended to conduct a direct survey to estimate the amount of food waste in the trade sector. However, the answers to nearly all enquiries – of both retailers and the federal association – contained a reference to a previously published study by the EHI Retail Institute GmbH. It was therefore impossible to obtain additional data.

The study conducted by the EHI Retail Institute GmbH shows that the German food retail trade is affected by a turnover loss of 1.1 percent per year in lost food, which corresponds to approx. 310,000 tonnes per year (EHI Retail Institute GmbH, 2011). This amount does not contain food given to charities. The true food losses in the retail sector are thus higher and amount to approximately 500.000 tonnes per year. It is undisputed that giving food to charities and food banks is a meaningful way to avoid waste that can possibly be intensified.

The amount of waste established for the wholesale sector, for which wholesale markets were analysed by means of an example, was approximately 43,500 – 87,000 tonnes per year. This corresponds to approximately 0.5 percent of the amount handled each year. However, this fluctuation margins covers only organic waste and in some cases also includes plant and flower waste disposed of together with food. Due to this inhomogeneous composition of the

amount of organic waste, the actual amount of food disposed of at German wholesale markets is likely to be smaller.

2.3.4 Large-scale consumers

The amount of waste from large-scale consumers has been calculated both in general and for the individual types of management among large-scale consumers. Wherever possible, several calculation approaches were stated within the individual types of management to be better able to assess the scale.

Table 1 shows a summary of the results for the individual management types and for large-scale consumers in general with the respective reference year. The catering industry accounts for the largest share of food waste from large-scale consumers with its range having been calculated to be between 837,000 and 1,015,000 tonnes per year. However, it was only possible to apply one approach for the calculation of this range as further information on food waste per capita from literature varies greatly. The second largest amount of food waste among large-scale consumers comes from in-company catering with between 147,000 and 402,000 tonnes per year, followed by the accommodation sector with 186,000 tonnes per year. Retirement and nursing homes account for 93,000 to 145,000 tonnes of food waste per year, followed by schools with 75,000 to 87,000 tonnes per year and hospitals with 65,000 tonnes per year. Food waste from universities, day-care centres for children, prisons and the German armed forces (*Bundeswehr*) are estimated at less than 41,000 tonnes per year each.

The comparison of the results from the different calculation routes shows that the level of food waste from large-scale consumers gathered by adding the individual sectors and by the general projection across the entire sector is comparable. Total food waste is between 1,500,000 and 2,298,000 tonnes. The fluctuation margin results from the above-mentioned uncertainty related to the data and could be only be reduced by more in-depth studies.

It was not possible to estimate to which extent the food waste was avoidable or unavoidable on the basis of the literature for individual management types at hand. According to Müller (1998), approximately 56 percent of food waste from large-scale consumers is avoidable and approximately 48.5 percent according to information provided by Baier and Reinhard (2007).

When applying the more current value of 48.5 percent, 756,600 to 1,114,530 tonnes of food waste from large-scale consumers would be avoidable.

Table 1: Results of the projection of food waste by management type of large-scale consumers and by consumers in general (np…no projection possible)

Large-scale consumers	*Total amount of food in 1,000 tonnes (rounded)*	*Reference year*	*Data basis*
Catering industry	837 - 1015	2009	Number of visits (Deutscher Fachverlag, 2011); Food waste (Engström, 2004)
Accommodation sector	186	2009	Number of overnight stays (Federal Statistical Office, 2010); Food waste (Part, 2010)
Hospitals	65	2009	Number of beds and occupancy rate (Federal Statistical Office, 2011e); Food waste (Part, 2010)
Schools	75 - 87	School year 09/10	Share of students participating in lunch according to National Food Consumption Survey (2008) and Food Waste (Part, 2010); Number of persons per school type (Federal Statistical Office, 2011f) and Food waste (Pladerer et al., 2010)
Large-scale consumers	*Total amount of food in 1,000 tonnes (rounded)*	*Reference year*	*Data basis*
Childcare facilities	34 - 38		Number of children having lunch (Federal Statistical Office, 2011g) and food waste (Part, 2010); Number of children (Federal Statistical Office, 2011g) and food waste (Pladerer et al., 2010)
Universities	41	WS 09/10	Share of students eating in canteen according to National Food Consumption Survey (2008), number of students (Federal Statistical Office, 2011d) and food waste (Part, 2010).
Retirement and nursing homes	93 - 145	2009	Nursing home figures (Pfaff, 2011b), food waste (Müller, 1998) and (Part, 2010), number of facilities for care (Federal Statistical Office, 2011)

Large-scale consumers	*Total amount of food in 1,000 tonnes (rounded)*	*Reference year*	*Data basis*
In-company catering	147 - 402	(2011)	Number of employed persons (Federal Statistical Office, 2011i), share of employed persons eating in in-company canteen according to National Food Consumption Survey (2008), food waste (SBG/IKS Dresden zit. in Wille et al., 2002) and (Van Bambeke, 2008).
Armed forces	7 - 10	09/10 - 09/11	Number of dishes served (Bundeswehr, 2011) and food waste (Müller, 1998) and (Part, 2010)
Prisons	17	MW 09/10/11	Number of prisoners (Federal Statistical Office, 2011j), food waste according to survey being part of the study
Rail and air traffic	np		
Other facilities with catering service	np		
Total for large-scale consumers	1,502 – 2,006		
Large-scale consumers in general	1,724 – 2,298	2009	Visits to out-of-house businesses (Deutscher Fachverlag, 2011)
	1,830 – 2,025	2009	Number of servings according to Hilger (2000) continued

2.3.5 Private households

Table 2 summarises the projections of the amounts of food waste from households in Germany. An estimated 5.05 million tonnes of food waste is discarded via the municipal waste collection system each year, i.e. along with residual waste or in organic waste containers. This corresponds to 62 kg/(E*a) per capita. Approximately 70 percent of this amount is found in residual waste or in organic waste containers. However, this amount corresponds only to a small part of the total food waste as it is also disposed of through other routes such as self-composting, feeding to pets or in the sewer system. However, due to the uncertain data we can only roughly estimate the additional amounts being disposed of through these routes. It ranges between 0.75 and 2.49 million tonnes per year or between 9 and 30 kg/(E*a). It is not possible to make a reliable estimation as to how much of this

amount is attributed to self-composting, sewer system and feeding. Therefore Table 2 provides only ranges on the basis of literature values within which that level is likely to lie.

Table 2: Amount of food waste from households in Germany

	er capita kg/(E*a)		Germany in total in million tonnes		Family of four kg/a	
	from	to	from	to	from	to
In the municipal collection system	**61.8**		**5.05**		**247.2**	
of which in residual waste	42.7		3.49		170.8	
of which in organic waste containers	19.1		1.56		76.4	
Other disposal routes	9.2	30.4	0.75	2.49	36.8	121.6
Self-composting	0.0	18.0	0.00	1.47	0.0	72.0
Sewer system	4.0	19.0	0.33	1.55	16.0	76.0
Feeding	0.0	3.0	0.00	0.25	0.0	12.0
Total	**71.0**	**92.2**	**5.80**	**7.54**	**284.0**	**368.8**

* based on a population figure of 81.75 million (as of late 2010; Source: Federal Statistical Office Germany, 2011)

The total amount of food waste from households in Germany per year is between 5.8 to 7.5 million tonnes. Taking the median value of this range in order to simplify, the annual amount of food waste is 6.7 tonnes or **81.6 kg/(E*a)** of which about **three quarters (76 percent) enter the municipal waste collection system.**

This figure corresponds to a large degree with the findings by Cofresco (2011) which calculate 6.6 million tonnes or approx. 80 kg/(E*a) for Germany without beverages. By international comparison the projection for Germany lies within the range of the results by van Westerhoven and Steenhuisen (2010) who calculated 73 kg/(E*a) of food waste for the Netherlands and by Langley, et al. (2010) who calculated an amount of 71 kg/(E*a) (0.199 kg/(E*d)) from 13 households in the United Kingdom. However, the results by WRAP for the UK (2009) are much higher with 330 kg per household and year (corresponds to approx. 140kg/(E*a)[1]).

[1] Converted using a household size of 2.36 (Office for National Statistics, 2011)

Table 3: Avoidability of household food waste in Germany

	Percentage by weight	Per capita kg/(E*a)		Total Germany in million tonnes		Family of four kg/a	
		from	to	from	to	from	to
In the municipal collection system	**100 %**	**61.8**		**5.05**		**247.2**	
unavoidable	35 %	21.6		1.77		86.5	
partially avoidable	18 %	11.1		0.91		44.5	
avoidable	47 %	29.0		2.37		116.2	
Total (all disposal routes)	**100 %**	**71.0**	**92.2**	**5.80**	**7.54**	**284.0**	**368.8**
unavoidable	35 %	24.9	32.3	2.03	2.64	99.4	129.1
partially avoidable	18 %	12.8	16.6	1.04	1.36	51.1	66.4
avoidable	47 %	33.4	43.3	2.73	3.54	133.5	173.3
Σ avoidable and partially avoidable	65 %	46.2	59.9	3.8	4.9	184.6	239.7

Table 3 shows that **47 percent of food waste is avoidable** and that **18 percent is partially avoidable**. This corresponds to 2.37 million tons or 29 kg/(E*a) of avoidable food waste in the municipal collection system and 0.91 million tonnes or 11.1 kg/(E*a) of partially avoidable food waste. In addition there is waste being disposed of through other routes. Taking again the median value for the sake of simplicity, the total amount is 3.14 million tonnes or 38.4 kg/(E*a) of avoidable food waste and 1.2 million tonnes or 14.7 kg/(E*a) of partially avoidable food waste.

Figure 7 displays household food waste broken down by its avoidability according to Figure 2.

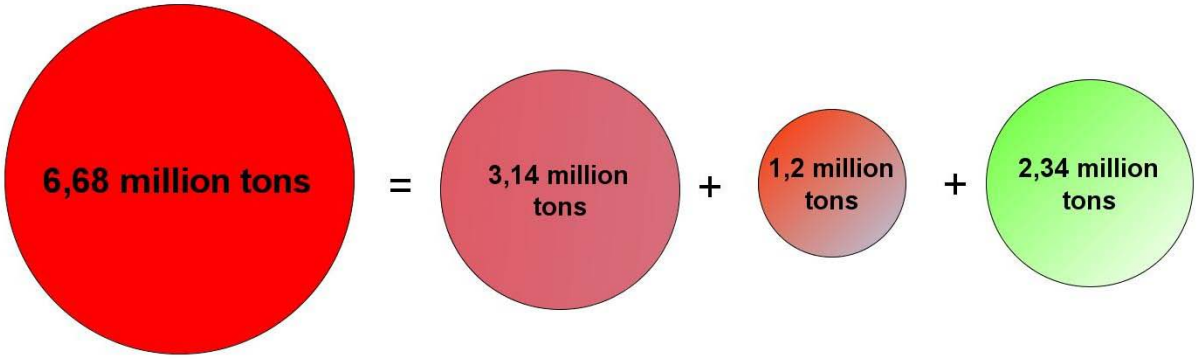

Figure 7: Amount of food waste from households in Germany

This result, too, matches the results by Cofresco (2011) according to which 36 percent of food waste was unavoidable and 59 percent avoidable. However, the study by Cofresco (2011) did not distinguish partially avoidable food.

Due to a lack of sufficiently detailed and representative data for Germany, only an approximate estimation on the composition of food waste for each product group can be carried out (on the basis of data by Cofresco [2011] and Barabosz [2011]). Figure 8 shows the composition of avoidable and partially avoidable food waste. Fruits and vegetables make up the largest share of avoidable and partially avoidable food waste.

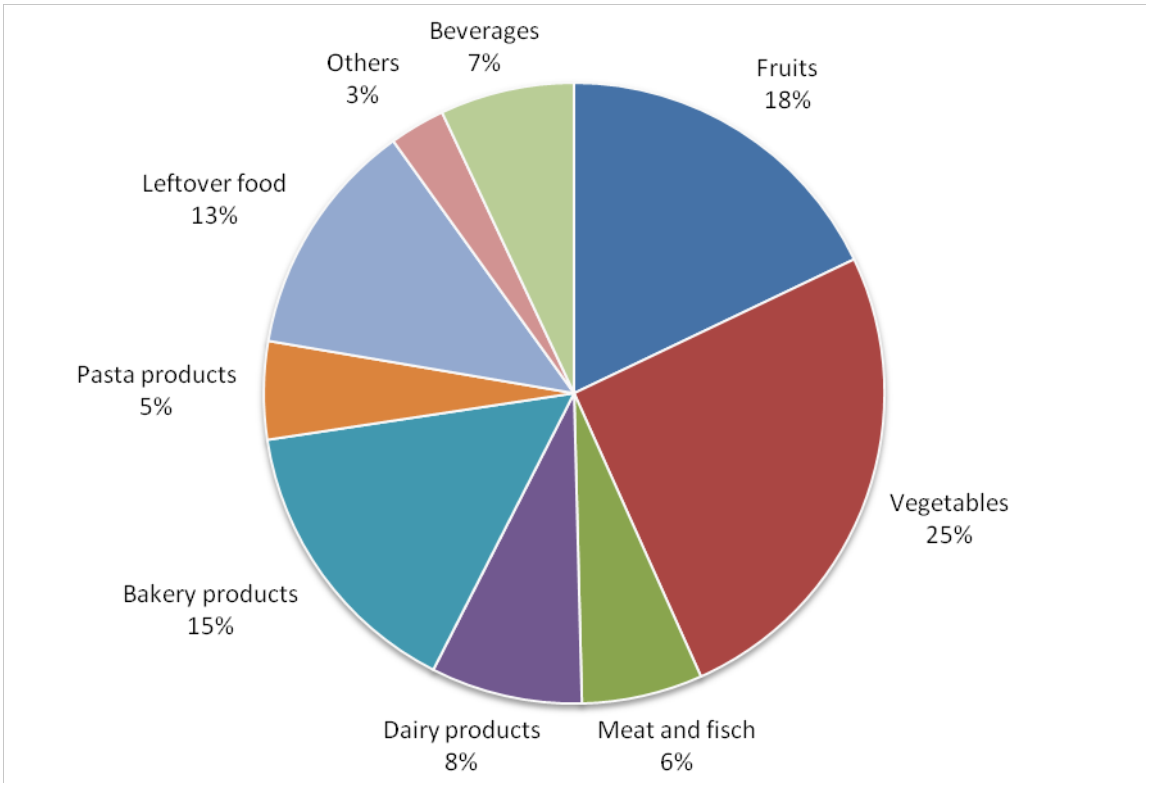

Figure 8: Composition of avoidable and partially avoidable food waste from households in Germany by product group (percentage by weight)

The amount of **avoidable and partially avoidable food waste** from households in Germany **corresponds** to a **monetary value of 16.6 to 21.6 billion EUR** per year or approx. **200 to 260 EUR per capita and year** (cf. Table 4). For an **average household of four**, this means that each year avoidable and partially avoidable food waste worth **approximately 935 EUR is disposed of as residual waste, in organic waste containers and the sewer system, through self-composting or fed to pets**. Private consumer spending for food and non-alcoholic beverages by German households in 2010 totalled 151.14 billion EUR

(Statistisches Bundesamt Deutschland, 2011). This means that avoidable and partially avoidable food waste accounts for between **10 and 14 percent of expenditures for food and non-alcoholic beverages**.

Table 4: Monetary value of avoidable and partially avoidable food waste from households in Germany

Monetary value of avoidable and partially avoidable food waste	Per capita EUR/(E*a)	Total Germany in billion EUR	Family of four EUR/a
Range	203.5 263.8	16.6 21.6	814 1,055
Mean value	233.7	19.1	934.6

Cofresco (2011) calculated that food worth 308.85 EUR per capita is discarded annually in Germany. However, this figure also includes unavoidable food waste that accounts for approx. 35 percent by weight of food waste. Both estimations give the same range when taking this into account. By international comparison the projection for Germany lies within the range of the results by WRAP (2009) for the United Kingdom according to which an equivalent of 231 EUR of avoidable food waste is discarded annually per capita corresponding to 15 percent of household expenditure for food, and by Baker, et al. (2009) which calculated an a value of 180 EUR per capita for Australia. Katajajuuri, et al. (2011) established that 4.5 percent of household expenditures in Finland are spent on avoidable food waste.

2.4 Identifying data gaps and need for research

Given that food waste from the food industry, trade and large-scale consumers is not subject to the obligation to tender delivery, public sector bodies do not record any quantities. Verified statistical data on waste is therefore frequently unavailable and we must draw upon figures published in literature and other surveying methods such as sorting analyses.

Obstacles to data gathering and data and knowledge gaps and thus the need for further surveys for the individual areas are set out in the following.

2.4.1 Food industry

- A definition of food waste in the industry is either not uniform or does not exist
    - What is food waste?
    - The distinction between avoidable / unavoidable food waste cannot be generalised but depends on the sector of business.
- Data are not collected in some cases because it would involve costly and time-consuming procedures.
- Where data is gathered according to the ISO standard or EMAS as part of an environmental audit, frequently only the entire flow of waste is surveyed. Differentiation of food waste is uncommon.
- The distinction drawn between by-product and waste is inconsistent.

2.4.2 Retail & Wholesale

- There are different data recording systems in food retailing. While the losses of some food retail businesses are determined via the net cost value of foods, others are determined via the (gross) sales value of written off foodstuffs.
- It is difficult to categorise in food retailing. Making distinctions between food categories is frequently impossible. Food articles also contain, in part, other product groups such as
    - tobacco (up to five percent),
    - animal feed,
    - chemist's shop articles, as appropriate, depending on the recording system of the branch store,
    - magazines, as appropriate, depending on the recording system of the branch store.
- There is reluctance to furnish information, notably by larger food retail businesses or discounters. Thus, the overall situation can only be estimated.
- Food waste is not explicitly recorded on wholesale markets. Only organic waste is more or less known as mass-flow rate.
- Existing data differ in quality.

2.4.3 Large-scale consumers

- The number of persons eating in canteens or receiving meals in hospitals, residential care homes for the elderly, prisons and other establishments is available for individual enterprises, but not for Germany as a whole.
- Up-to-date surveys are needed in the hotel and restaurant industry because there were major changes in recent years according to the German Hotel and Restaurants Association (DEHOGA).
- Up-to-date nationwide surveys in individual fields such as schools and childcare facilities, residential homes for the elderly and nursing homes, business catering and the armed forces are also necessary in order to restrict the size range.
- Different overall situations in the *Länder* (e.g. in the case of penal institutions) hinder data comparison.
- Data on other establishments offering food such as sports and cultural events or all sorts of recreational fairs and data on air and rail travel in Germany are largely lacking.

2.4.4 Private households

- The percentage of food waste throughout Germany is not known.
- The percentage of food waste in the fine and medium fractions < 40 mm, especially in the fine fraction is not known. In Austria, a study on residual waste is currently underway, a corresponding study is lacking in Germany.
- Poor knowledge of the proportion of food waste from households in organic waste bin (hardly any data from Germany).
- No data is available on the proportion of food waste in the medium and fine fraction in the organic waste bin.
- Data on the composition of food waste (in residual waste) broken down by avoidability does not exist.
- The quantity of food waste that is not disposed of in the municipal collection system, but composted at home, fed to pets or discharged into the sewer system is not known.

All in all, harmonisation of definitions, surveying methods, and benchmarks for food waste are needed in all fields.

3 Proposals for a minimization of food wastage

3.1 Reasons for the development of food waste

Food waste arises along the entire value-added chain. This can be attributed to various causes, which are elaborated below. The reasons identified by consulting the relevant literature are summarised according to the sectors considered in this research project.

3.1.1 Food industry

Foodstuffs that do not comply with certain **product and quality characteristics** are sorted out (Monier, et al., 2010). This includes, for example, irregularly shaped or sized products that are not suitable for certain processes.

Food waste also arises during **quality assurance operations**. For example, food-processing enterprises must take **samples** and keep those **retained samples** in order to be able to check and to prove the perfect quality of their products throughout the whole shelf life. The samples and retained samples are then disposed of (Schneider, 2009; Escaler, et al., 2011).

Moreover, the loss of edible food results from or is facilitated by **overproduction** or **poor planning**. Reasons therefore include **irregular demand** or **returned sales** (Mena, et al., 2011).

Technical problems may also constitute a reason for food waste (Monier, et at., 2010). Errors in the production process lead to defective or damaged products, which can no longer be sold (e.g. faulty batches, production losses). Another source of waste is the **spillage** of products, which for example occurs during the filling of liquid food (Gustavsson, et al., 2011). In addition, **damaged packaging** causes food to spoil faster (Parfitt, et al., 2010), while technical problems occasionally cause **incorrect labels**.

According to Monier (2010), much food waste arises during the processing stage due to

legal restrictions or **commercial standards**. The partial elimination of marketing standards for fresh food (European Commission, 2008) could significantly reduce the amount of food unnecessarily disposed of before being traded.

3.1.2 Retail & Wholesale

There are various reasons for food disposal by the trade as well.

According to Stenmarck (2011), food is mainly disposed of by the trade because it is or becomes "**unsalable or unmarketable**." This includes food with an expired best-before or use-by date as well as perishable food that is often not labelled with a date such as bread, fruits and vegetables. High demands on the quality, freshness, and the appearance of such foodstuffs often influence the customer's purchasing decision. In many cases, this food is no longer considered "**sellable**" due to a lack of freshness. Most of these reasons result from the customer's (consumption) behaviour.

However, certain sales targets also constitute reasons for food waste. Thus, a huge variety of goods and shelves that are always completely filled are also responsible for overproduction and oversupply of food (Gustavsson, et al., 2011). Stenmarck (2011), however, points out that consumers *expect* the shelves to be filled. Retailers are therefore forced to order more goods (causing increased production) than they actually sell.

Examples given by Stenmarck (2011):

- **Overproduction** of fresh baked goods: Interviews show that more baked goods are produced than are expected to be sold during the day in order to meet the customers' demand (up to 7 percent extra).
- **Damage** to perishable food: Fruits and vegetables are often presented stacked up in the sales room. This causes fruits or vegetables lying at the bottom or on the rim to be dented or even damaged, which then causes them to be disposed of. Moreover, if a fruit starts to rot, the putrefaction may spread to the adjacent fruits.

Traders often use different **marketing strategies** for food with a short shelf life or to reduce excess stocks (Monier, et al., 2010). Particular mention should be given in this regard to the "buy one get one free" (BOGOF) offers, which are very common in the United Kingdom. Such

marketing strategies could lead the food to be shifted from retail waste to households.

Several reasons can be attributed to trade organisation. Challenges and difficulties involved in an ideal merchandise information system or in demand-based stock planning have to be identified and addressed by traders. According to Stenmarck (2011), the order process is one of the main problems at the moment. However, this process will be improved in the future due to technical appliances. It is, for example, difficult to order the **proper amount** of food at the correct time. This applies to all foodstuffs but is especially difficult with respect to fresh or perishable food. The consumer's purchasing behaviour is influenced by various factors such as **weather**, **season**, **special offers,** and **personal attitude**. The fact that it is very difficult to predict the consumer's demand leads to excess stocks (Monier, et al., 2010). New and improved systems allowing predictions of purchasing behaviour are being developed and will contribute to a better adaption of the supply of goods to the actual demand of the customers in the future.

Inadequate or **improper handling** of food also represents plenty of reasons, especially regarding **storage** under **insufficient temperature** or **lighting conditions**. Similarly, **improper positioning** of the foodstuffs may also cause them to spoil faster, which makes them no longer **saleable** or **marketable**. For example, storing avocados next to tomatoes makes them ripen more quickly (Stenmarck, et al., 2011; Monier, et al., 2010).

Many of the reasons mentioned above also apply to the wholesale trade. Of particular significance is, however, the **improper handling** with foodstuffs, which constitutes a major reason for their losses. Foodstuffs are, for example, damaged due to improper handling and therefore can no longer be sold (Stenmarck, et al., 2011). Damaged packaging is another reason that food is disposed of despite being undamaged. The aim here must be to develop better packaging in order to reduce these damages.

According to Monier (2010), **excess stocks** in wholesale lead to a disposal of edible food as well. These excess stocks result for instance from redemption agreements (relating to unmarketed foodstuffs) with retailers or from orders that are cancelled at short notice. These excess stocks should be reduced because otherwise the food becomes unmarketable.

3.1.3 Large-scale consumers

With respect to large-scale consumers, the reasons for food waste are quite similar. For example, reasons arise from internal organisation, regarding services for customers, and in the kitchen.

One cause of this is insufficient knowledge in internal organisation about the emerging amount of waste. The introduction of **key figures for waste management** could be an effective measure suited to counteract this lack of knowledge.

In the kitchen, **inadequate storage** and **different degrees of processing** of the products are the main causes of waste. An increased amount of fresh ingredients results in increasing amounts of cleaning and preparation waste. A lack of **calculation** basics regarding the number of the meals to be prepared is another reason for the development of food waste. Only few kitchen chefs have recourse to data on pre-confirmed dishes. Thus, they have to rely on their experience. Much food waste arises when institutions **do not reuse** prepared but not yet served food. Up to 80 percent of food is not reused in institutions such as canteens. However, soups, potatoes, or raw salads among others are used again. Insufficient **awareness** regarding the development of food waste is also a cause. Another reason is the level of costs for goods and materials employed (although in the literature this assumption is not considered to be statistically significant).

With respect to the customers, factors include **menu selection**, **serving size** and **type** of the portions offered. The more individual customers are addressed, the more likely will they finish their meal. Further reasons for food waste are **hygiene and food safety regulations** concerning the passing on and reutilisation of food (e.g. compliance with the cold chain) as well as **lack of information** (for example Muslim or vegetarian customers want to know whether or not the meal contains pork or meat).

3.1.4 Private households

Certain **developments in society** play an important role in the disposal of food in private households. Many trends and developments, such as the almost constant availability of an oversupply of foodstuffs, a major drop in consumer expenditures for foodstuffs, or the

growing alienation towards food, create an environment that facilitates the disposal of food.

Individual reasons on a personal and household level are very diverse. They cannot be generalised as they depend on the product as well as on the way of life and the living conditions of the households. Studies conducted to date have produced very different results and are of limited value as most studies predefine the reasons, leading the results in a certain direction. There are no theoretical studies based on empirical results or theoretical foundations. A good overview of the broad range of reasons is provided in the studies of Glanz (2008) and Selzer (2010).

According to Glanz (2008), consumers most often referred to:

- special ingredients (foodstuffs used rarely or only for certain meals, seasonal products) (10 out of 21 households)
- inadequate storage (incorrect storage conditions, incorrect storage by mistake, infestation of moths) (10 out of 21 households)
- lack of knowledge of stocks (9 out of 21 households)
- own production and presents (foodstuffs given as a present and not used, excessive crop yields from the own garden) (8 out of 21 households)
- food that was already spoiled before it was bought, freshness and taste (preference of freshly bought products), products for any eventuality (stocks for guests and certain meals), trial purchase (to test a new product) (7 out of 21 households each)

According to Selzer (2008):

- attitude (freshness/taste, do not want the same again, want to have the choice, want to clear out, did not pay attention when shopping, health issues)
- and an excessive amount of incoming goods (lack of inventory knowledge, special offers, presents from guests)

The importance of a possible amendment to the **best-before date** is overrated in public debate. To date, no studies have been conducted showing that a lack of understanding of this term is directly connected to a large amount of food thrown away by households. However, experience has shown that an expired best-before date is one reason for throwing food away.

It seems that the best-before date is of certain relevance because it is used as a criterion that

determines when the product is disposed of. This means that in case of doubt, people often decide to throw the product away when the best-before date has expired. These cases seem to be based on a psychological reflex as well. However, the question arises why people do not consume foodstuffs before the best-before or use-by date has expired. The most important questions are: How can we make sure that food is consumed on time and that the best-before date is not regarded as a "throw away date" in practical life? And: What further information do consumers need in order to prevent the food from becoming spoiled before the best-before or use-by date has expired due to incorrect storage or cooling?

Therefore, awareness raising campaigns – for example with the help of the flyer “Plate or Bin? Information on the best-before date” by the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) – should be continued and, if necessary, extended in combination with other measures that address the underlying reasons (BMELV, 2012).

3.2 Strategies and concepts to reduce the amount of food discarded in other countries

With a view to working out proposals to reduce the amount of food thrown away in Germany and to point out options for action in order to implement various measures in the individual food chain sectors, the research team, first of all, researched existing measures at home and abroad. Existing measures were identified with the help of the literature and Internet research, through scientific exchange and expert consultations, and by interviewing individual initiators of preventive measures.

These include concrete preventive measures, scientific papers, political acts, technical products, and social initiatives (food distribution programmes). Not all initiatives covered are aimed at reducing food waste. Individual projects pursue other objectives, as a matter of priority, such as a reduction of packaging waste in retail trade or sustainability campaigns in enterprises. Yet, they can result in a decrease in food waste by creating synergy effects. In this regard, pilot projects to optimise processes in the food industry or initiatives for sustainable consumption are worth mentioning, for example.

A total of 360 preventive measures were identified. These were classified, described and their results, if any, compiled.

An assessment system (utility analysis) was developed in order to make preventive measures of the same category comparable. Particular regard was given to the transferability of the measures to Germany.

The results show 34 promising approaches, which are described in detail in the long version of this project. Compiled as a best practice catalogue, it identifies specific options for action and recommendations to prevent food waste.

3.3 Recommendations for action

Food waste should be permanently reduced at all stages of the food value-added chain. In the interest of sustainable consumption, the appreciation for food needs to be enhanced in large sections of the population. The recommendations for action provide food chain policy-makers, consumers, and stakeholders with reference points for decision-making when conceiving successful strategies for reducing food waste.

Drawing up a national **roadmap** represents a major step. This roadmap would foster the creation of the necessary framework conditions for preventing food waste in Germany.

First of all, **objectives were articulated** (along the same lines as the *Roadmap to a resource-efficient Europe: halving food waste by 2020* (European Commission, 2011). An **agenda for action** was devised as the next step. This agenda sets out measures that will help meet the objectives. Afterwards, a **research agenda** will be devised in order to close existing gaps in data and knowledge.

3.3.1 Key recommendations

The active involvement of all relevant stakeholders in the food chain (agriculture, industry, trade, households, restaurant and catering sector, policy-makers, educational establishments, social institutions, etc.) is needed in order to halve avoidable food waste by 2020. A high level of acceptance and the involvement of all stakeholders can only be secured by **objectifying the debate**. This can be done, for one, by determining reliable figures through the research agenda and, secondly, by **avoiding apportionment of blame**.

Joint and expedient implementation of the preventive measures primarily requires a great willingness of all stakeholders to communicate and an open and trusting approach in the provision of experience, information, and knowhow. To this end, all stakeholders must engage in intensive networking throughout the food chain and transcend the limits of individual stages of the value-added chain. It is strongly recommended that **round table talks** will be held involving all relevant stakeholders in the value-added chain, e.g. farmers, producers, distributors, large-scale consumers (mass and institutional caterers, catering firms, hotel and restaurant industry), final customers, churches and environmental, educational and social welfare organisations (FOOD, SCP, 2009).

The farming sector, food industry, retail trade, hotel and restaurant industry, scientific community, and policy-makers can be brought together by initiating an **Internet-based network** for reducing food waste. Alongside an exchange on innovative technologies and solutions, the most innovative collaborative activities of participating businesses will be conferred with an award. Furthermore, the participants will benefit from the reciprocal exchange of experience and from neutral advice (No Waste Network, 2011).

The subject of food waste represents a major element towards increasing the regard in which foodstuffs are held. **Platforms on more sustainability in the food chain** are the key to coping with future challenges arising in the provision of food supplies (Foresight, 2011). We should strive for a more environment-friendly design of foods and greater transparency in the value-added chain (Verduurzaming Voedsel, 2009).

A database of **best practice measures** from the food chain, in the form of an open source, will enable the stakeholders to benefit from the experience gained from successfully implemented measures. In addition, such a portal can be used as an advertising medium for the enterprise's own projects and thus boost the image of the enterprise itself (Experiencebox, 2007).

Enterprises are called upon to take food waste into account in their environmental management systems and to **identify it in their environmental statements**. It should be examined whether food waste ought to be considered, in future, as a sub-criterion in various environmental certification schemes or when awarding environmental standards.

The subject matter should be integrated in training schemes in the fields of production,

processing, trade, and catering trade. Incentives should be provided for holding of and staff participation in **training schemes, advanced vocational training, and workshops**. Staff members should be encouraged to act as disseminators and role models in the responsible handling of food.

In order to estimate and assess developments in the prevention of food waste and relevant action, constant collection of data or **monitoring** are essential. Based on scientific findings, these should be rapidly developed and introduced.

In spite of all the measures presented here, it will not be possible to completely prevent food waste. Even if a substantial reduction proves possible, foods will still be disposed of as waste. It is therefore absolutely necessary to leave the quantities generated in the substance cycle and to use their energy content, as appropriate. Depending on the suitability, food waste should be **composted** or used to produce renewable energy (**biogas production**). We should aim at expanding separate biowaste collection with a view to the recycling of food waste. This is also enshrined in the new Closed Substance Cycle and Waste Management Act (KrWG) (Deutscher Bundestag, 2012), which will make the separate collection of biowaste mandatory as of 1 January 2015.

3.3.2 Recommendations for the food industry

Operational and process optimisations are key steps towards achieving sustainable production. Small and medium-sized enterprises (SMEs) in particular frequently lack capacities for implementing optimisation measures. A generation of knowhow and the **provision of advice on resource-efficient management** and optimised material flow management can provide assistance to SMEs. This could take the **form of an association or a network**. Members thereby obtain extensive advice on sustainable production and resource efficiency (Green Business, 2010).

Voluntary undertakings by the food industry and food retail trade have significant mitigation potential, as testified by the Courtauld Commitment from the United Kingdom (1.1 million tonnes of avoided food and packaging waste (Swannell, 2010)). A similar undertaking by the German food industry and food retail trade would be a very welcome development and

just as exemplary.

3.3.3 Recommendations for the retail sector

The food retail trade is required to play its part as a key link between production, processing, and consumers. It can play a major role in providing information and raising awareness. The inclusion of **regional products** in the range of goods shortens transport routes and is also very popular with consumers. **Highlighting bargains** for products that are nearing their best-before date is an appropriate instrument to reduce avoidable food waste. Some supermarkets even give away products that have reached their best-before date to their customers (Billa, 2011; Jumbo Supermarkten, 2011). Many donate them to welfare services.

Individual supermarkets pursue the strategy of selling **their products without any packaging** (Unpackaged, 2006; in.gredients, 2011). A partial adaptation of this concept to larger food retailers should be considered. Part of the product range, at least, could be offered and sold unpackaged. This would encourage customers to buy food in accordance with their actual needs (loose products instead of large packs).

Further development of logistic and ordering tools is necessary, in order to simplify and optimize the product ordering system. Incorrect orders and excessive order volumes can be minimised by training staff. **Research into dynamic best-before dates** based on compliance with the cold chain and quality of foods would similarly be welcomed.

The concept of **day-before bakeries** that only offer bakers' wares of the previous day can be an important factor in reducing avoidable bakery waste (FAZ, 2011). The same is true for the **happy hour concept**. Here, the products are offered at sharply reduced price levels shortly before closing time.

3.3.4 Recommendations for large-scale consumers and the hotel and restaurant industry

Initiation of a hotel and restaurant industry federation with the aim of awarding environmental standards (certificates) to participating hotels and restaurants. Award-winning enterprises must meet sustainability standards and are allowed, in turn, to use the awards to attract business. Another objective is the inclusion of stakeholders in a type of "**Green Tourism Map**." This map will help eco-conscious travellers find sustainable hotels and restaurants (Green Hospitality, 2008).

In most cases, knowhow about the composition and amount of waste generated on a daily basis in large-scale kitchens results in the decrease of food waste in businesses. A **quantitative coverage of waste and simple feedback system** to cooks would raise awareness and point out potential for prevention (Leanpath, 2006; Sodexo USA, 2010).

Guides and other sources of information on sustainable management in catering facilities and on the reduction of food waste should be devised for the hotel and restaurant industry and made available free of charge (Unilever Food Solutions, 2011; Creedon, et al., 2010). **Tools for alternative or optimised waste management** can offer the hotel and restaurant industry solutions and alternatives for better disposal of their waste (EPA, 2009).

A portal on resource-efficiency in the healthcare system has great potential for curbing waste and promises major pecuniary advantages for the participants. Success can be achieved by **optimised material flow management** (Daxbeck, et al., 2007) and **innovative catering systems** (Snels, et al., 2011). Knowhow on the adaptation of optimal preventive measures must be generated and establishments should be provided with advice when implementing the measures.

3.3.5 Recommendations for private households

Raising awareness about the issue of food waste is the precondition for successfully avoiding waste. As a first step, this should be done via **media campaigns** in order to reach as much of the population as possible. Additional consumer information and advice to avoid waste should be communicated via **internet-based platforms**. Note that it is necessary to deal with

the diverse reasons and causes of food waste (Glanz, 2008). For example, one instrument could be a cooking tool to calculate proper serving sizes (Love Food Hate Waste, 2008) or additional information on the correct storage of food (Still Tasty, 2009).

The practical implementation of different concepts aimed at avoiding food waste in the form of pilot projects conducted at regional or local level is a new approach to solving this problem. The objective is to establish effective measures taking into account different framework conditions (e.g. settlement structure, social aspects, age groups, urban and rural areas, etc.). In this way, different measures can be compared for their effectiveness and the most suited projects can be analysed to see whether they could be transferred to the national level (Bos-Brouwers, et al., 2011). Pilot projects for the groups of persons involved have in general proven to be a sustainable measure to reduce food waste.

Existing initiatives or innovative ideas should be highlighted and prizes awarded by calling for a competition to avoid food waste. In addition to consumers, other participants in the food chain could also participate in such a competition.

3.4 Need for research in Germany

There is a need for research at different levels to achieve a more sustainable supply and to successfully reduce food waste. This need shall be presented and described here as an example.

The task of the scientific community is primarily to **fill data gaps**, to help simplify future surveys and to establish a **single data collection method**. Developing and establishing a **monitoring system** would significantly improve the collection of food waste data in the future. Research projects at individual stages of the food chain can help **optimise the processes and operations**. It is also desirable to **develop tools and sources of information** to avoid food waste by enterprises.

The Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) has already launched an **additional analysis of robust data** for the **agricultural sector**. The logistics sector should also be analysed in more detail to estimate the amount of food waste. What is needed is to study post-harvest losses, quantify the amount of food that does not enter the

market and to find out why, to establish the loss of animal products and to analyse the loss in storage in agriculture. Losses caused during distribution (e.g. due to a disruption of the cold chain) should also be ascertained.

Pilot projects on optimising processes and operations at different stages of food production should be encouraged and promoted (meat, dairy products, etc.).

Optimised ordering systems and avoidance of incorrect orders could reduce food losses in the trade sector. It is necessary to review the (further) development of a **logistics tool to optimise the commodity flow**.

In future, dynamic food labelling could replace existing labelling such as the best-before date. By reacting to disruptions in the cold chain (through time temperature indicators, TTI), such labels could provide more precise information about the food's quality. It would then be possible to **compare the effects on the presence of food waste between standard food labels and dynamic food labels**.

The following research projects could be conducted among large-scale consumers:

- A feasibility study on the **adaptation of innovative catering systems** in the German health sector.
- Developing best practices for different sectors of gastronomy and catering.
- Analysing **potentials to prevent food waste in air traffic** and optimising the use of unavoidable organic waste.
- Developing different tools for optimised management of food.

For the target group of private consumers, it seems pertinent to develop and identify **practical schemes for the reduction of food waste** under different framework conditions.

It is also necessary to analyse the interaction between food law and food waste with the inclusion and support of different stakeholders. Legal and logistical barriers to the fight against food waste should be identified as a matter of urgency and possible approaches to overcoming these barriers should be developed.

Moreover, it is recommended to draft a **guideline on donating food to welfare services**. This can help to simplify the donations of food that is no longer marketable to welfare services or to strengthen cooperation.

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