

# FOOD FUTURES – REFLECTIONS ON THE ENGINEERING THEME WASTE MANAGEMENT

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**SUMMARY:** Based on understanding that food poses one of the key challenges for future development in the coming decades, integrated research on the complex topic of food systems is recognized to be essential. Activities and concepts aiming to reduction of waste and losses of food are considered to be most promising options among possible measures to improve food security. Occurrence of losses and waste varies much in different regions, which highlights the necessity to study the topic by region, although the global perspective is essential. Initiatives for driving improvements have highest potential for success if they involve multi-stakeholder engagement under consideration of the existing food supply chains. Post-consumer waste is often the most visible food wastage proportion, and its reduction is often given priority by governments, NGOs and civil society especially in industrialized countries. Food losses along the whole supply chain are more difficult to quantify, and the research and development actors have responsibility to initiate advances towards sustainability along the whole chain.

## 1. INTRODUCTION

Global production of food has significantly increased over the past five decades. Currently there is sufficient food production for all, but distribution of food and availability of adequate nutrition are unequal throughout the world. Increase of population along with changing consumption patterns of wealthier populations will result in significantly higher demand for food in the coming decades. Productivity is only one aspect of the challenge to supply food to where it is needed, and it will be essential to understand the interactions and various feedback effects within complex food systems. A food systems approach systematically connects the activities involved in food systems (producing, processing, distributing, marketing, preparing and consuming food) with food security and other outcomes (social welfare, environmental welfare) in order to provide a framework for understanding the interactions between food security and other stresses and for clarifying decision making processes for appropriate policy options (Ingram et al., 2011).

In April 2013, around 30 postdoctoral researchers ('Young Scientists') with diverse research perspectives were brought together for several days to reflect on the topic 'Food Futures' during the 'Future Earth' Young Scientists Networking Conference on Integrated Science, organized by the International Council for Science (ICSU), the German Research Foundation (DFG) and the International Social Science Council (ISSC). The meeting at the German-Italian Centre for

Cultural and Scientific Exchange Villa Vigoni aimed at fostering interdisciplinary collaboration and interaction with innovative thinkers on a global scale. The conference was also joined by several Senior Scientists and scientists from the organizing institutions. 'Future Earth' is the international framework designed by the international science bodies ICSU and ISSC for conducting integrated science around three themes: The Dynamic Planet, Global Development and Transformation towards Sustainability. The research and additional activities of Future Earth are to be co-designed by the community of researchers including natural and social sciences, engineering and humanities in partnership with stakeholders in order to close the gaps between environmental research and policies and practices.

Waste management was not an explicit topic to be discussed during the Food Futures conference, but the topic was addressed where relevant. The layout and main contents of this presentation have their starting point at the participation as Young Scientist at the Food Futures conference with the knowledge exchange during the working sessions and additional information flows. Review of a range of questions by consultation of scientific literature provides a deeper understanding of relevant factors. In a last section of this presentation some issues are further addressed by reporting results from a questionnaire which was sent to the participants of the Food Futures conference a few days after the conference. The main aim of this presentation is to focus light on key aspects of the waste management tasks within the food security topic and in reference to a food systems approach, under special consideration of the engineering tasks in a research perspective.

## **2. FOOD WASTE**

### **2.1 Definitions**

When agricultural activity aims at production of food for human consumption, its edible output is in general regarded as the baseline parameter when referring to food losses along the following food supply chain (FSC). There is no consensus what the terms food loss or food waste comprise. Food is a biological material experiencing degradation or requiring processing before consumption, so occurrence of material unsuitable for serving as food is to some extent unavoidable. But available food crops might also be diverted into alternative utilization pathways such as feeding livestock, other by-products and biofuel, depending on market conditions and local demands. Outgrading of food which does not meet cosmetic or quality criteria might also be an important issue, and one which is difficult to quantify both in terms of amounts and of alternative utilization pathways (which might include entering the food processing chain for different purpose than foreseen). Possible definitions for food wastage used in various studies are as follows, with the first two considered most relevant (Parfitt et al., 2010):

- Edible material destined for human consumption that is discarded, lost, degraded or consumed by pest at any point in the food supply chain
- As above, but including edible material that is intentionally fed to animals or is a by-product of food processing diverted away from human consumption
- As above, but including over-nutrition as the gap between the energy value of consumed food and the one needed per capita

At later stage of the FSC in general the term food waste is applied and generally relates to behavioural issues. During earlier stages of the FSC waste is often referred to as food losses and spoilage. Food losses/spoilage to a significant extent relate to systems that require an engineered environment with investment in infrastructures and equipment. In line with the majority of relevant literature, in the following the term food waste relates to all stages of the FSC.

The terms 'food supply chain' FSC and 'post-harvest system' are both used in literature to

describe in general the same (agricultural system and the onward supply of products to markets), with the first expression being more common in industrialized countries and the second more common in agricultural environments (Parfitt et al., 2010). The term post-consumer food waste characterizes all food wastage from activities at the point at which food is consumed (e.g. meal preparation waste). In complementing this, the term pre-consumer waste would include the three other main stages of the FSC: agricultural waste/ residues (e.g. left on field), food processing residues (e.g. peels) and food distribution waste (e.g. damaged products).

## **2.2 What is lost?**

Wastage of food is in general reported by weight, although alternative approaches look at lost calorific value, or/and associated consumption of natural resources and mainly water, arable land and fertilizer (Kummu et al., 2012).

While post-consumer waste is the most precise to be defined, wastages at other points of the FSC are more difficult to be classified, as mentioned above. In a supply chain, food waste might therefore refer to all material which does not enter the destined market, which would e.g. include produce which due to minimum characteristics might not be sold as foreseen, but would be accepted by the local consumer. While data on post-consumer food waste is now available for several regions, and (although not easy to be implemented with precision) an understanding of methods for its determination has been developed, data on waste produced at various points of the FSC are still scarce. The problem of limited availability of reliable data has been recognized to be a crucial issue on a global scale. It has been highlighted by Parfitt et al. (2010) that many data from developing countries might contain overestimations, due to different reasons: extremes are taken rather than averages, removal from stores due to other reasons is not well accounted and inventory might be limited, and partial damage might be classified as loss. In addition most studies refer to data collected during previous decades, which might be outdated and imprecise. Further risks of inaccuracies seem to be related to food flows on international scale, where imported and exported quantities need to be regarded. In the manufacturing sector information might be of commercial sensitivity for the food industry, which might explain the lack of available data in this area e.g. for the EU27 countries (Pfaltzgraff et al., 2012).

It is often quoted that as much as half of all food grown is lost or wasted before and after it reaches the consumer. Recent publications assume that these amounts are overestimated and losses might be more in the range of a quarter to a third (Kummu et al., 2012; Parfitt et al., 2010) – which still means huge amounts. To better understand the current situation, the relevant uncertainties and the possible measures, more precise and updated data would be a prerequisite.

## **2.3 Global patterns and trends, and main causes for occurrence of food waste**

Occurrence of food waste can be partially linked to availability of technology in a country, the nature of the market, and general awareness and attitude. This is not a steady state but changes along changing economies and societies, and the design and efficiency of FSCs. Aside of aging population profiles and growth in single person households in industrialized countries, Parfitt et al. (2010) have identified three interrelated main drivers influencing FSCs:

- Urbanization and contraction of the agricultural sector. – The increasing urban population requires extended FSCs, which includes improvements in transportation and marketing infrastructures.
- Dietary transition. – Growth in household incomes results in less consumption of starchy food and higher demand for fresh fruit and vegetables, dairy, meat and fish. This means a shift towards vulnerable, shorter shelf-life items.
- Increased globalization of trade. – While globalization opens opportunities for agricultural

exports, it represents a threat to internal markets by creating inexpensive food flows.

In developing countries the highest losses occur at the post-harvest stage(s). Research data for South Africa indicate that from a total of 31% of wasted food the vast majority (96%) occurs at the pre-consumer stage (with about equal amounts for the steps agricultural production, post-harvest handling/storage, and processing/packaging, and a somewhat lower amount during distribution), and only as little as 4% at the actual post-consumer stage (Oelofse and Nahman, 2013). In industrialized countries substantial waste occurs in households after purchase, although retail, distribution and processing remain responsible for significant amounts of waste (Godfray et al., 2010). Pfaltzgraff et al. (2012) cite from literature that in the EU27 more than 70% of the agricultural goods are used to be transformed into food industry products, and that 38% of all EU27 food waste is produced by the food manufacturing sector. When moving from low- to middle-income status, reduction of waste early on the food chain has been observed in many countries, although these gains are in some cases mitigated by increasing waste generated by consumers and retail (Godfray et al., 2010). Transformation follows a different route in each country and is strongly linked to activities of retailers (Parfitt et al., 2010).

When looking at the causes for food waste, it can be summarized that in low-income countries the connection is mainly to financial, managerial and technical limitations in harvesting techniques, storage and cooling facilities, transport infrastructures, and in packaging and marking systems, whereas in medium and high income countries the connection is mainly to consumer behaviour and to a lack of coordination between different actors in the supply chain (Gustavsson et al., 2011; Oelofse and Nahman, 2013).

## **2.4 Sustainability issues focused under a technology perspective**

Local FSCs are mentioned as being relatively sustainable: they support mixed and organic farming, reduce negative environmental impacts created by long-distance transports, generate rural income and foster rural communities, break agribusiness monopolies, and create spiritual links between man and nature (Smith, 2008). More industrialized FSCs result in complex systems with often fluctuating and intransparent interdependencies, and increasing challenges not only to achieve but also to define sustainability criteria. Definition of a baseline sustainability standard is non-sense (Smith, 2008), and simply trying to communicate sustainability messages to consumers might among others reflect ignorance of the actual consumer (Casimir and Dutilh, 2003), which might implicate activities under unconsciousness of gender issues – and hence would be of negative impact on sustainability. This to some extent should also be considered when breaking down responsibility for food waste to the individual household level. Post-consumer food waste is in general the most visible food waste, especially from the consumer's perspective (Pfaltzgraff et al., 2012). However, upon perception of lack of activities along the whole FSC with neglected responsibility of stakeholders to address more complex interdependencies, it is questionable if at all the consumer is willing (and will remain willing) to respond to awareness raising campaigns.

There is full consensus that efficient waste management is a major issue in sustainability of food supply chains. It has been assessed that by more efficient utilization of already available technologies and instruments approximately half of the food losses could realistically be prevented compared to the current situation (Kummu et al., 2012). As already pointed out, the causes for waste vary much for different stages of the FSC. While some stages have received or are currently receiving much attention (e.g. agriculture, consumer), there are fewer studies especially for the more complex stages. There seems to be a particular lack of information at the interfaces of the stages, e.g. the supplier-retailer interface (Mena et al., 2011). The current state of knowledge indicates that it is not only important to identify efficient measures to reduce occurrence of waste, but that it is first relevant to make available more precise data and to

increase understanding of the implications of the topic along the whole food chain. Mixing and short-term substitution processes along complicated dynamic supply networks may be a special challenge for traceability of components and for efficient flow of information and influence along the more industrialized chain (Smith, 2008).

Various actors hold power to initiate and advance sustainability in the FSC. It has been understood that in progress towards more sustainable supply chains emphasis of governmental and civil society organizations is to demand that manufacturers and retailers act as responsible corporate citizens and use a mixture of science, business rationale, politics and cognitive marketing rather than just making appropriate products available and call to consumers to buy green (Smith, 2008). In a country such as the UK, supermarkets have been identified as holding the gate-keeper role to the food chain, and hence are expected to use their influence towards more sustainability in the food system, while in countries where the retail sector is more fragmented (e.g. Indonesia), manufacturers are seen to hold best opportunities to exert influence along the whole chain (Smith, 2008, citing literature).

Highest potential for driving improvements is associated with multi-stakeholder initiatives involving governments, farmers, academics, NGOs and food business, and in which each of the actor is able and willing to provide complementary skills, approaches and networks under consideration of the type of food chain, as described by Smith (2008). While some of the actors hold high potential to advance on local scale or address directly to end consumers, others hold potential and are called to adopt a holistic approach and advance on a wider scale. Certainly the academic sector with its research and development responsibilities holds potential to be a key driver towards developing more sustainable food supply chains by dedicating engagement into activities which provide a better understanding of sustainability issues linked to farming and food processing, and by developing technologies to improve the whole system and its security, e.g. by tracking or tracing techniques.

When assessing the demands of more sustainable food systems, it is evident that the technology and engineering perspective is still and will remain important, and this is also the case when directly addressing the food waste problem. Reduction of food losses was already a topic when the FAO (Food and Agriculture Organization) was established in the year 1945. Activities addressing world hunger included looking at reduction of post-harvest food losses. In the 1980s the FAO Special Action Programme for the Prevention of Food Losses initially aimed at grain, but was then broadened to include roots, fruits and vegetables. The focus was purely technical, but adoption rates for intervention were poor, which led to understanding that technology does have an essential role to play, but is by itself insufficient for solving the problems within the sector – which was a starting-point to developments of more holistic approaches (Grolleaud, 2002). This is still essential when considering today's pressing engineering tasks towards more sustainable food systems, including closing loops through recycling of wastes and bioenergy production, innovative technology and improvement of engineered infrastructures along the FSCs, and understanding the interlinks with consumption of resources and security issues.

### **3. RESULTS OF THE FOOD FUTURES QUESTIONNAIRE**

Being embedded in the Future Earth framework, the Food Futures conference can be understood as an element to make a contribution towards research design and identification of promising pathways in the field. The assembled participants represent a diversified academic research-orientated group with at least some understanding of the requirements for more sustainable food systems. Main aim of the questionnaire was to gain a first insight into awareness of the topic waste management among the members of such a group. The online-questionnaire included 10

questions to be answered ad-hoc and was sent to 45 participants of which 31 responded. 3 data sets were incomplete and were excluded. Fully completed questionnaires were received from 22 Young Scientists, 5 Senior Scientists and 1 Member of the Management/Organizer.

Based on the classification of subject areas by DFG most participants grouped themselves into the category ‘Life Sciences’, followed by ‘Humanities and Social Sciences’ (Table 1). 50% of answers came from participants from Europe (Figure 1). Around one third indicated expertise for low- and low-middle-income-countries, one quarter for upper-middle-income countries and nearly 80% for high-income economies (Table 2).

Table 1. Academic disciplines of respondents to the Food Futures questionnaire.

<p><b>Based on the classification of subject areas by DFG (<a href="http://www.dfg.de/en/dfg_profile/statutory_bodies/review_boards/subject_areas/index.jsp">http://www.dfg.de/en/dfg_profile/statutory_bodies/review_boards/subject_areas/index.jsp</a>) I group myself in the following area of expertise (please decide for 1 answer under consideration of your overall professional qualification and areas of previous/ongoing activities)</b></p> <p>Answered: 28 Skipped: 0</p>	
Answer Choices	Responses
Humanities and Social Sciences (including Economics, Political Science)	32.14% 9
Life Sciences (including Medical Research, Medicine, Plant Sciences, Agriculture, Forestry)	35.71% 10
Natural Sciences (including Chemistry, Geography, Water Research)	17.86% 5
Engineering	3.57% 1
None of these categories/ My work has become too interdisciplinary to allow me a decision for one of these options	10.71% 3
Total	28

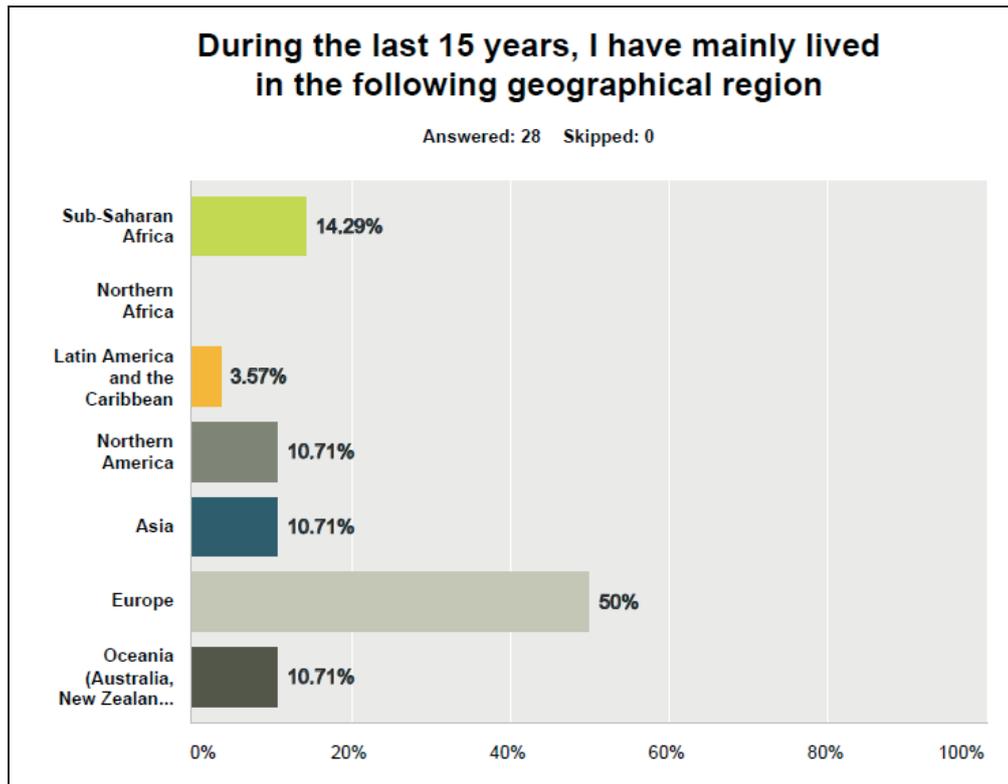


Figure 1. Geographical region of respondents

As revealed by the data provided with Table 3, 86% of respondents indicated that their work is at least to a significant degree related to science and education, 43% indicated this for the public sector, 36% for the individual consumer, and 32% for the political sector.

As further shown in Table 3, the activities of 64% of respondents are linked to direct consumption of food to at least a significant extent. Food production practices are directly relevant for 57% of the respondents, and processing/distribution for 50%, while 54% of respondents address general environmental factors to a significant extent.

Table 2. Overview of specific experience of respondents with view to countries in different economic development status.

<p style="text-align: center;"><b>I have either lived for at least 1 year during the last 10 years in one or several of the following countries or have gained considerable working experience (e.g. country specific project with duration of at least 2 years) for at least one of the following countries (multiple answers possible; note: country grouping based on the world bank system: <a href="http://data.worldbank.org/about/country-classifications/country-and-lending-groups">http://data.worldbank.org/about/country-classifications/country-and-lending-groups</a>)</b></p> <p style="text-align: center;">Answered: 28 Skipped: 0</p>	
Answer Choices	Responses
<p>Low-income economies (\$1,025 or less; Afghanistan, Gambia, The Mozambique, Bangladesh, Guinea, Myanmar, Benin, Guinea-Bissau, Nepal, Burkina Faso, Haiti, Niger, Burundi, Kenya, Rwanda, Cambodia, Korea Dem Rep., Sierra Leone, Central African Republic, Kyrgyz Republic, Somalia, Chad, Liberia, Tajikistan, Comoros, Madagascar, Tanzania, Congo Dem. Rep. Malawi, Togo, Eritrea, Mali, Uganda, Ethiopia, Mauritania, Zimbabwe)</p>	17.86% 5
<p>Lower-middle-income economies (\$1,026 to \$4,035; Albania, Indonesia, Samoa, Armenia, India, São Tomé and Príncipe, Belize, Iraq, Senegal, Bhutan, Kiribati, Solomon Islands, Bolivia, Kosovo, South Sudan, Cameroon, Lao PDR, Sri Lanka, Cape Verde, Lesotho, Sudan, Congo Rep., Marshall Islands, Swaziland, Côte d'Ivoire, Micronesia, Fed. Sts., Syrian Arab Republic, Djibouti, Moldova, Timor-Leste, Egypt Arab Rep., Mongolia, Tonga, El Salvador, Morocco, Ukraine, Fiji, Nicaragua, Uzbekistan, Georgia, Nigeria, Vanuatu, Ghana, Pakistan, Vietnam, Guatemala, Papua New Guinea, West Bank and Gaza, Guyana, Paraguay, Yemen Rep., Honduras, Philippines, Zambia)</p>	17.86% 5
<p>Upper-middle-income economies (\$4,036 to \$12,475; Angola, Ecuador, Palau, Algeria, Gabon, Panama, American Samoa, Grenada, Peru, Antigua and Barbuda, Iran Islamic Rep., Romania, Argentina, Jamaica, Russian Federation, Azerbaijan, Jordan, Serbia, Belarus, Kazakhstan, Seychelles, Bosnia and Herzegovina, Latvia, South Africa, Botswana, Lebanon, St. Lucia, Brazil, Libya, St. Vincent and the Grenadines, Bulgaria, Lithuania, Suriname, Chile, Macedonia FYR, Thailand, China, Malaysia, Tunisia, Colombia, Maldives, Turkey, Costa Rica, Mauritius, Turkmenistan, Cuba, Mexico, Tuvalu, Dominica, Montenegro, Uruguay, Dominican Republic, Namibia, Venezuela RB)</p>	25% 7
<p>High-income economies (\$12,476 or more; Andorra, Germany, Oman, Aruba, Greece, Poland, Australia, Greenland, Portugal, Austria, Guam, Puerto Rico, Bahamas The, Hong Kong SAR China, Qatar, Bahrain, Hungary, San Marino, Barbados, Iceland, Saudi Arabia, Belgium, Ireland, Singapore, Bermuda, Isle of Man, Sint Maarten, Brunei Darussalam, Israel, Slovak Republic, Canada, Italy, Slovenia, Cayman Islands, Japan, Spain, Channel Islands, Korea Rep., St. Kitts and Nevis, Croatia, Kuwait, St. Martin, Curaçao, Liechtenstein, Sweden, Cyprus, Luxembourg, Switzerland, Czech Republic, Macao SAR China, Trinidad and Tobago, Denmark, Malta, Turks and Caicos Islands, Estonia, Monaco, United Arab Emirates, Equatorial Guinea, Netherlands, United Kingdom, Faeroe Islands, New Caledonia, United States, Finland, New Zealand, Virgin Islands (U.S.), France, Northern Mariana Islands, French Polynesia, Norway)</p>	78.57% 22
Total Respondents: 28	

Table 3. Links of professional activities of questionnaire respondents to different sectors and to basic factors relevant in sustainable food systems.

<b>My areas of research/ professional activities are related to</b>				
Answered: 28 Skipped: 0				
	not at all	very little	to a significant extent	with priority
<b>The political sector</b>	25% 7	42.86% 12	21.43% 6	10.71% 3
<b>The public sector including municipalities</b>	25% 7	32.14% 9	32.14% 9	10.71% 3
<b>Industry and private sector</b>	14.29% 4	39.29% 11	39.29% 11	7.14% 2
<b>Science and education, communication</b>	0% 0	14.29% 4	42.86% 12	42.86% 12
<b>The individual consumer</b>	10.71% 3	53.57% 15	21.43% 6	14.29% 4

<b>The food systems approach systematically connects the activities of food producers, processors, distributors, retailers and consumers. My areas of research/ professional activities are linked to</b>				
Answered: 28 Skipped: 0				
	not at all	very little	to a significant extent	with priority
<b>General environmental factors and availability of resources (water, land)</b>	21.43% 6	25% 7	17.86% 5	35.71% 10
<b>Food production practices</b>	10.71% 3	32.14% 9	35.71% 10	21.43% 6
<b>Processing and distribution of food</b>	21.43% 6	28.57% 8	39.29% 11	10.71% 3
<b>Consumption of food</b>	7.14% 2	28.57% 8	32.14% 9	32.14% 9

Below 40% of respondents indicated that the topic waste management is of at least significant relevance in their work, while 36% do not at all address the subject in their professional activities (see Figure 2).

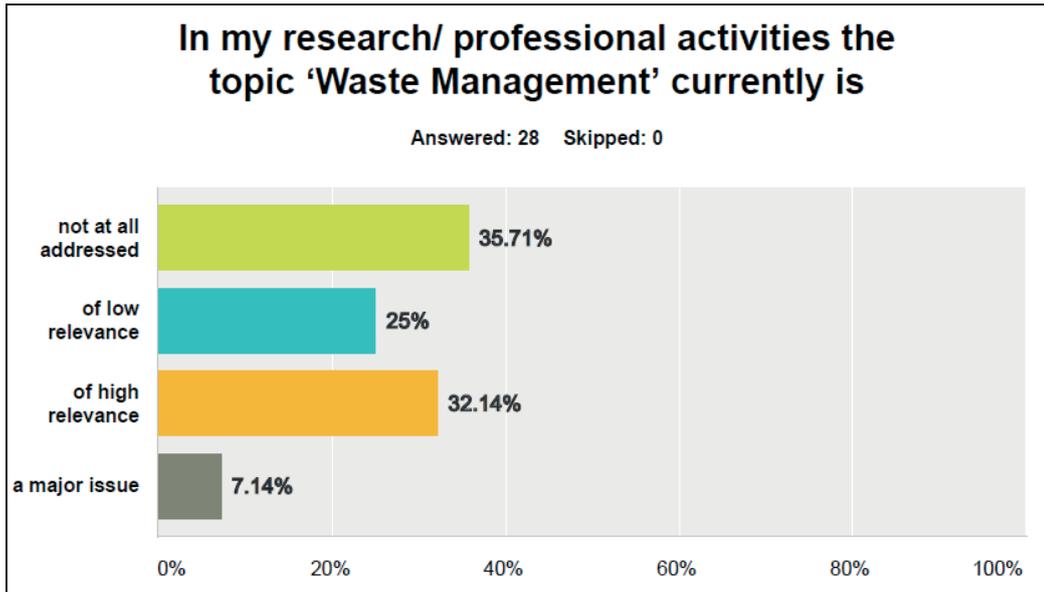


Figure 2. The topic waste management in current professional activities of respondents

When asked about understanding occurrence of food waste along the food supply chain, only 7 to 11% of respondents indicated that they do not have a clear understanding where in the following sectors of the food supply chain significant wastage occurs: agriculture, transport/storage, retail/supermarkets, and households (see Table 4). But 21% indicated lack of understanding where wastage occurs in the food processing stage.

Table 4. General understanding where food waste occurs along the food supply chain.

**I have a clear idea/understanding where in the following sectors significant amounts of food waste occur (please provide an answer for each sector)**

Answered: 28 Skipped: 0

	strongly disagree	somewhat disagree	neutral	somewhat agree	strongly agree
<b>Agriculture</b>	3.57% 1	3.57% 1	17.86% 5	42.86% 12	32.14% 9
<b>Processing/ Industry</b>	7.14% 2	14.29% 4	14.29% 4	50% 14	14.29% 4
<b>Transport/ Storage</b>	3.57% 1	3.57% 1	14.29% 4	46.43% 13	32.14% 9
<b>Retail/ Supermarkets</b>	3.57% 1	3.57% 1	21.43% 6	42.86% 12	28.57% 8
<b>End Consumers (households/ catering/ restaurants)</b>	3.57% 1	7.14% 2	21.43% 6	21.43% 6	46.43% 13

It is interesting to note that the majority of respondents (54%) indicated that participation in the conference is likely to have the effect that they will increase consideration of the topic waste management in their own work (see Table 5). When excluding those who currently do not at all address waste issues (resulting data not depicted here), 61% of the participants will give stronger consideration to the topic.

In sum the majority (54%) feel that the conference has increased their general awareness of the topic and of its relevance to sustainable food systems, and an equal percentage of participants indicated that they have gained a better understanding of the dimensions along the whole food supply chain (data depicted in Table 5). When again excluding those who do not at all address waste issues in their work, the percentages increase to 61% (higher general awareness for food waste issues) and 66% (better understanding for implications along FSCs). 61% of respondents indicated they have gained a better understanding of the engineering tasks (there is no change in percentage after excluding those who do not at all deal with waste).

Table 5. Assessment of how participation in the Food Futures conference influenced the participants with view to different factors related to the topics waste management and engineering aspects in food systems.

<b>My participation in the Food Futures networking conference</b>					
Answered: 28 Skipped: 0					
	<b>strongly disagree</b>	<b>somewhat disagree</b>	<b>neutral</b>	<b>somewhat agree</b>	<b>strongly agree</b>
Has increased my understanding of the engineering tasks in the current and future food systems	7.14% 2	10.71% 3	21.43% 6	39.29% 11	21.43% 6
Has increased my general awareness that the topic waste management is highly relevant when looking at future food systems and food security	3.57% 1	14.29% 4	28.57% 8	25% 7	28.57% 8
Has increased my awareness on the different dimensions of the topic food waste along the whole food supply chain	3.57% 1	14.29% 4	28.57% 8	35.71% 10	17.86% 5
Is likely to have the effect that I will give more consideration to the topic 'Waste Management' in my own research/ working activities	7.14% 2	7.14% 2	32.14% 9	28.57% 8	25% 7

It is clear from summarizing these results that even among a group of academic professionals with at least partial background knowledge for food issues, there is high potential to raise awareness for the topic food waste along the FSC. It is further clear that there is high willingness to integrate the topic into own research and professional activities.

When looking at the responses to which factors are regarded to likely be beneficial towards reducing food waste (Table 6), those measures related to technology are assessed more positive. 88% of participants consider scientific and technical innovations to hold potential, and 86% indicate this for transfer of technical know-how and know-how on good agricultural practices. 79% assess influences on the behaviour of consumers to be likely beneficial, 75% indicate education and better understanding, 71% market instruments, and 68% policy issues.

Table 6. Assessment of beneficial effects of different factors towards reduction of food waste.

<p><b>Based on my expertise and assessment, I assume the following factors to be beneficial towards reduction of food wastage (please answer each row; in case you feel an option is missing or would like to provide further comments, please use the comments space at the end of the questionnaire after Question 10)</b></p> <p>Answered: 28 Skipped: 0</p>					
	very unlikely	somewhat unlikely	neither likely nor unlikely	somewhat likely	very likely
Policy innovations/ implementation of adapted and focused policies	3.57% 1	10.71% 3	17.86% 5	32.14% 9	35.71% 10
Market instruments (e.g. economic incentives for reduction of food waste)	3.57% 1	7.14% 2	17.86% 5	32.14% 9	39.29% 11
Scientific and technical innovations	0% 0	0% 0	14.29% 4	57.14% 16	28.57% 8
Transfer of technical know-how/ know-how on good agricultural practices	0% 0	0% 0	14.29% 4	60.71% 17	25% 7
Education/ better understanding of the interlinks in the food supply system	0% 0	10.71% 3	14.29% 4	28.57% 8	46.43% 13
Influencing the behaviour of the food consumer	0% 0	7.14% 2	14.29% 4	32.14% 9	46.43% 13

It is however interesting to note that those respondents who had grouped themselves into the discipline ‘Humanities and Social Sciences’ regard policy issues together with technology transfer as holding most potential for beneficial effects (89% positive assessment for both factors). It is further interesting to note that among respondents experienced in low-income economies and lower-middle-income economies, 100% indicated technical innovations, transfer of technical know-how and on good agricultural practices, education and increase of understanding of the FSC, as well as influencing behaviour of consumers to be likely beneficial towards reduction of food wastage (while policy and market instruments ranked lower).

#### **4. CONCLUSIONS**

Waste reduction is an important way to increase food supply and food security, and at the same time to decrease the negative environmental impacts of current food supply. Although post-consumer waste is the most visible proportion of lost food, waste occurs along the whole food supply chain and due to various reasons. There is not only a lack of precise data for food waste at various points of the food chain but also a lack of initiatives to address responsibility along the whole food supply chain.

The results of the Food Futures questionnaire provide evidence that even among academics with professional background in food related topics, awareness for the issues of waste management and associated technologies is limited. This indicates general potential to increase understanding of implications along the food supply chain and of relevance of the issues for research towards implementation of more sustainable food systems.

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