UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Understanding food waste behaviours along the food supply chain: a multilevel approach

Raquel Diaz-Ruiz

INSTITUTE FOR Sustainability Science AND TECHNOLOGY

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

CREDA CENTRE DE RECERCA EN ECONOMIA I DESENVOLUPAMENT AGROALIMENTARI

Doctoral program in Sustainability

Phd Dissertation

Understanding food waste behaviours along the food supply chain – a multilevel approach

Phd Candidate: Raquel Diaz-Ruiz

Directors:
Dr. Jose M. Gil
Dr. Montserrat Costa-Font

Barcelona September 2018

ABSTRACT

The visibility of the food waste volume along the food supply chain during the recent years has situated this topic in the policy and research agenda. Food waste entails environmental, ethical and economic impacts. There is a broad agreement on the urgency of reducing the current food waste generation. However, there are still several knowledge gaps to better achieve it. Its complexity requires in-depth analyses, including multiple dimensions and adopting a multi-actor approach, to better understand its causes and to select the most adequate of solutions. There is a lack of whole-supply approaches and multidimensional consumers' understanding. To fill these gaps, the main objective of this thesis is to explain the factors influencing the food waste generation, as well as to explore potential measures to prevent and reduce the current food waste generation at different stages of the supply chain. This thesis is structured into two main parts. The first one considers the whole food supply chain while the second focusses at the household level. The specific objectives of the thesis are: 1) to analyse the causes of food waste generation and its circumstantial or structural nature along the food supply chain; 2) to identify and prioritize food waste prevention and reduction measures along the food supply chain; 3) to better understand consumer food waste behaviour by considering a multidimensional model; and 4) to critically analyse in-home consumer food waste measurement and the effect of framing and information on consumers' perception of food waste generation.

To achieve these objectives both quantitative and qualitative methods are employed. The thesis is divided into four chapters. The first part (chapter 1 and 2) utilised a multi-stakeholder panel along the food supply chain to analyse the causes of and solutions to food waste in the metropolitan region of Barcelona. In-depth interviews and a Delphi survey were employed. The second part (chapter 3 and 4) includes two consumer surveys, one in the Barcelona metropolitan region, and the other in the United States (US). The first survey tested and validated a multidimensional behavioural model to explain consumers' food waste behaviour using the Partial Least Square - Structural Equation Modelling (PLS-SEM). The second employed a survey experiment methodology.

This thesis addresses the food waste debate from an innovative and holistic perspective. Chapters 1 and 2 provide meaningful evidence to understand the structural nature of food waste generation and to find out solutions to prevent and reduce it by addressing the complex root of the phenomenon. The causes of food waste are classified as macro, meso, and micro. Chapter 2 discusses the regional stakeholder's proposals to prevent and reduce food waste by prioritizing them - following the hierarchy of food waste management- into strong prevention, weak prevention, and redistribution solutions. Chapter 3 and 4 offer innovative approaches to understand and accordingly address consumers' food waste. Chapter 3 proposes and validates a model that predicts food waste employing consumers' food-related behaviours, waste-related behaviour, environmental concern, and materialism values. Chapter 4 demonstrates the influence of different framings (volume, monetary, social, and environmental) in consumer's self-reporting of food waste, as well as the effect of information on their perception. Chapter 3 and 4 test different alternatives to measure consumer food waste generation. Overall, the thesis contributes to the growing body of literature by offering multidimensional approaches to analyse the food waste phenomenon, and it does so by providing first-hand data from each case study – which is very scarce nowadays. The findings are of significant interest to both policy bodies and researchers in the field of sustainable food system.

RESUM

La visibilitat durant els últims anys del malbaratament alimentari, generat al llarg de la cadena agroalimentària, ha situat aquest tema en l'agenda política i de recerca. El malbaratament alimentari comporta impactes ambientals, ètics i econòmics. Existeix un ampli consens en la urgència de reduir el malbaratament generat avui dia. No obstant, encara existeixen diversitat d'aspectes sense estudiar que ho dificulten. La complexitat del fenomen requereix d'una anàlisi en profunditat, incloent múltiples dimensions i diversitat d'agents, per entendre millor les causes i adoptar les millors solucions. Existeix una manca d'enfocaments de cadena i d'estudis multidimensionals en consumidors. El principal objectiu d'aquesta tesi és explicar els factors que influeixen en la generació de malbaratament alimentari, així com explorar potencials solucions per prevenir i reduir el volum de malbaratament generat en diferents etapes de la cadena agroalimentària. Per aconseguir aquest objectiu, la tesi s'estructura en dues parts principals. La primera considera tota la cadena agroalimentària i la segona es centra en les llars. Els objectius específics de la tesi són: 1) analitzar les causes del malbaratament alimentari i la seva naturalesa estructural o conjuntural al llarg de la cadena agroalimentària, 2) identificar i prioritzar mesures per a la prevenció i la reducció del malbaratament alimentari al llarg de la cadena agroalimentària, 3) entendre el comportament del consumidor en quant al malbaratament alimentari considerant un model multidimensional, i 4) analitzar críticament el mesurament del malbaratament alimentari en la llar i l'efecte que diferents dimensions i informació tenen en la percepció del consumidor sobre la seva generació.

Per aconseguir aquests objectius, es fan servir tant mètodes quantitatius com qualitatius. Les dues parts principals de la tesi es divideixen en quatre capítols. La primera part (capítol 1 i 2) utilitza un panell amb agents clau de la cadena agroalimentària per analitzar les causes i solucions al malbaratament alimentari a l'àrea metropolitana de Barcelona. Per a això s'empren entrevistes en profunditat i un qüestionari Delphi. La segona part (capítol 3 i 4) comprèn dues enquestes a consumidors, una a l'àrea metropolitana de Barcelona i una altra a Estats Units. La primera enquesta analitza i valida un model multidimensional de comportament del consumidor per mitjà d'equacions estructurals (PLS-SEM). La segona, aplica un mètode d'enquesta experimental.

La tesi aborda el debat del malbaratament alimentari des d'una perspectiva innovadora i holística. Els capítols 1 i 2 ofereixen evidències per entendre la naturalesa estructural del problema, així com per trobar solucions per prevenir i reduir el malbaratament dirigides a l'arrel del fenomen. El capítol 2 prioritza les propostes dels agents del cas d'estudi per prevenir i reduir el malbaratament (seguint la jerarquia de gestió del malbaratament) en prevenció forta, prevenció dèbil i redistribució. Els capítols 3 i 4 ofereixen un enfocament innovador per entendre, i en conseqüència abordar, el malbaratament alimentari del consumidor. El capítol 3 proposa i valida un model que prediu el malbaratament alimentari en funció de comportaments en alimentació, en gestió de residus, la consciència ambiental i els valors materialistes dels consumidors. El capítol 4 demostra la influència de diferents dimensions (volum, monetària, social i ambiental) en l'autoavaluació del malbaratament alimentari, així com l'efecte de la informació. Els capítols 3 i 4 examinen alternatives per mesurar el malbaratament alimentari del consumidor. En general, la tesi contribueix a la creixent literatura científica oferint enfocaments multidimensionals per analitzar el malbaratament alimentari, alhora que aportant dades primàries dels casos d'estudi.

RESUMEN

La visibilidad durante los últimos años del desperdicio alimentario generado, a lo largo de la cadena agroalimentaria, ha situado este tema en la agenda política y de investigación. El desperdicio alimentario conlleva impactos ambientales, éticos y económicos. Existe un amplio consenso en la urgencia de reducir el desperdicio generado hoy en día. No obstante, todavía existen múltiples aspectos sin estudiar que lo dificultan. La complejidad del fenómeno requiere de análisis en profundidad, que incluyan múltiples dimensiones y diversidad de agentes, para entender mejor las causas de éste y adoptar las mejores soluciones. Existe una carencia de enfoques de cadena y estudios multidimensionales en consumidores. El principal objetivo de esta tesis es explicar los factores que influyen en la generación de desperdicio alimentario, así como explorar potenciales soluciones para prevenir y reducir el volumen de desperdicio generado en diferentes etapas de la cadena agroalimentaria. Para lograr este objetivo, la tesis se estructura en dos partes. La primera engloba toda la cadena agroalimentaria y la segunda se centra en los hogares. Los objetivos específicos de la tesis son: 1) analizar las causas del desperdicio alimentario y su naturaleza estructural o coyuntural a lo largo de la cadena agroalimentaria, 2) identificar y priorizar medidas para la prevención y la reducción del desperdicio alimentario a lo largo de la cadena agroalimentaria, 3) entender el comportamiento del consumidor en cuanto al desperdicio alimentario considerando un modelo multidimensional, y 4) analizar críticamente la medición del desperdicio alimentario en el hogar y el efecto que diferentes dimensiones e información tienen en la percepción del consumidor sobre su generación.

Para lograr estos objetivos, la presente tesis emplea tanto métodos cuantitativos como cualitativos. Las dos partes principales de la tesis se dividen en cuatro capítulos. La primera parte (capítulo 1 y 2) emplea un panel de agentes relevantes de la cadena agroalimentaria para analizar las causas y soluciones al desperdicio alimentario en el área metropolitana de Barcelona. Para ello se desarrollan entrevistas en profundidad y un cuestionario Delphi. La segunda parte (capítulo 3 y 4) comprende dos encuestas a consumidores, una en el área metropolitana de Barcelona y otra en Estados Unidos. La primera encuesta analiza y valida un modelo multidimensional de comportamiento del consumidor por medio de ecuaciones estructurales (PLS-SEM). La segunda, aplica un método de encuesta experimental.

La tesis aborda el debate del desperdicio alimentario desde una perspectiva innovadora y holística. Los capítulos 1 y 2 ofrecen evidencias para entender la naturaleza estructural del problema, así como para encontrar soluciones para prevenir y reducir el desperdicio orientadas a la raíz del problema. El capítulo 2 prioriza las propuestas de los agentes del caso de estudio para prevenir y reducir el desperdicio (siguiendo la jerarquía de gestión del desperdicio) en prevención fuerte, prevención débil y redistribución. Los capítulos 3 y 4 ofrecen un enfoque innovador para entender, y en consecuencia abordar, el desperdicio alimentario del consumidor. El capítulo 3 propone y valida un modelo que predice el desperdicio alimentario en función de comportamientos en alimentación, gestión de residuos, la conciencia ambiental y los valores materialistas de los consumidores. El capítulo 4 demuestra la influencia de diferentes dimensiones (volumen, monetaria, social y ambiental) en la autoevaluación del desperdicio alimentario, así como el efecto de la información. Los capítulos 3 y 4 examinan alternativas para medir el desperdicio alimentario del consumidor. En general, la tesis contribuye a la creciente literatura científica ofreciendo enfoques multidimensionales para analizar el desperdicio alimentario a la vez que aportando datos primarios de los casos de estudios.

Acknowledgments

I would like to express my sincere gratitude to those who have accompanied me in one way or the other during this journey:

my supervisors José M. Gil and Montserrat Costa-Font

the colleagues who have contributed in some of the chapters of the thesis Feliu López-i-Gelats, Gnel Gabrielyan and David Just

the supervisors of my stages abroad David Just in Cornell University, and David Evans in The University of Sheffield.

my colleagues in CREDA

all the colleagues I met in Cornell and Sheffield

to all the colleagues in the Association Plataforma Aprofitem els Aliments

to all the colleagues who I have been working during these years on food waste

my family, specially to my parents and my sister

Román, my partner in life

my friends

And, last but not least, I would like to thank all people who participated in any of the interviews or surveys of the thesis. Without their participation it would have been impossible.

I would like to thank all the organizations who have funded the work presented in this thesis.

The Waste Prevention department of the Metropolitan Area of Barcelona partially funded some parts of this thesis in chapters 1, 2 and 3.
The Charles H. Dyson School of Applied Economics and Management partially funded the work in chapter 4.
I have been funded by the by the Ministry of Education, Culture and Sport of Spain with a Pre Doctoral teaching fellowship (FPU 13/06077) and two mobility fellowships for short stays and temporary transfers in the Charles H. Dyson School of Applied Economics and Management, in the S.C. Johnson College of Business at Cornell University in Ithaca, New York, USA from September 12, 2016 to December 11, 2016 (EST15/00193). And in the University of Sheffield hosted by the Department of Geography from September 4, 2017 to November 6, 2017 (EST16/00283).

Personal implication

I truly believe that food waste is a problem that should be addressed to contribute to more sustainable food systems.

Since I read the book 'Waste: Uncovering the Global Food Scandal' and saw the food waste reality in the Spanish context I committed myself to contribute to the problem from my personal and professional level.

During these years I have been developing this thesis, I have combined my research with my activity in the *Plataforma Aprofitem els Aliments*. It is a non-for-profit grass-root association located in Barcelona where we organize multiple ludic activities and debates to disseminate the importance of food waste and to make the society aware of it.

A part from my modest contribution to the academic field with this thesis, I would like to make the information it contains more "digestible" to the society in order to first, return to them the time invested in any of my studies, and two, to spread and disseminate the knowledge I could have gained during these years.

Table of content

INTRODUCTION - 17 -

OBJECTIVES - 22 -
THESIS STRUCTURE - 23 -
FOOD WASTE DEFINITION - 24 -
REFERENCES - 25 -

CHAPTER 1 - 31 -

1.1.INTRODUCTION - 33 -
1.2.THE CASE STUDY: THE METROPOLITAN REGION OF BARCELONA - 35 -
1.3.CONCEPTUAL FRAMEWORK TO DISTINGUISH STRUCTURAL AND CIRCUMSTANTIAL CAUSES - 37 -
1.4.MATERIAL AND METHODS - 38 -
1.5.RESULTS AND DISCUSSION - 40 -
1.6.CONCLUSIONS - 52 -
REFERENCES - 54 -

CHAPTER 2 - 59 -

2.1.INTRODUCTION - 61 -
2.2.MATERIALS AND METHODS - 64 -
2.3.RESULTS - 67 -
2.4.DISCUSSION - 69 -
2.5.CONCLUSIONS - 76 -
APPENDIX - 78 -
REFERENCES - 79 -

CHAPTER 3 - 83 -

3.1. INTRODUCTION - 85 -
3.2. THEORETICAL FRAMEWORK: FOOD WASTE BEHAVIOUR - 86 -
3.3. MATERIAL AND METHODS - 92 -
3.4. RESULTS - 95 -
3.5. DISCUSSION AND CONCLUSIONS - 102 -
REFERENCES - 106 -

CHAPTER 4 - 111 -

4.1. INTRODUCTION - 113 -
4.2. MEASURING CONSUMER FOOD WASTE - 115 -
4.3. THE DIMENSIONS OF FOOD WASTE - 116 -
4.4. MATERIAL AND METHODS - 117 -
4.5. RESULTS AND DISCUSSION - 122 -
4.2. CONCLUSIONS - 133 -
APPENDIX - 135 -
REFERENCES - 137 -

CONCLUSIONS - 141 -

List of tables

CHAPTER 1

TABLE 1.1 FOOD WASTE CAUSE-ANALYSIS STUDIES -34-
TABLE 1.2 SAMPLE CHARACTERISTICS -40-
TABLE 1.3 MICRO CAUSES OF FOOD WASTE -45-
TABLE 1.4 MESO CAUSES OF FOOD WASTE -48-
TABLE 1.5 MACRO CAUSES OF FOOD WASTE -50-
TABLE 1.6 FOOD REDISTRIBUTION DIFFICULTIES -52-

CHAPTER 2

TABLE 2.1. CHARACTERISTICS OF THE PANEL OF STAKEHOLDERS FOR THE TWO STAGES OF RESEARCH -67-
TABLE 2.2 MEASURES TO PREVENT AND REDUCE FOOD WASTE, DELPH RESULTS -70-
TABLE 2.3 FOOD WASTE IMPLEMENTATION HIERARCHY -75-
TABLE A2.1 COMPLETE STATEMENTS OF FOOD WASTE PREVENTION AND REDUCTION MEASURES -78-

CHAPTER 3

TABLE 3.1 SAMPLE DESCRIPTION -93-
TABLE 3.2 LATENT VARIABLES AND INDICATORS DESCRIPTION -97-
TABLE 3.3 RELIABILITY MEASUREMENTS -99-
TABLE 3.4 FORNELL-LARCKER TEST OF DISCRIMINANT VALIDITY -100-
TABLE 3.5 SIGNIFICANCE ANALYSIS OF THE STRUCTURAL MODEL -101-
TABLE 3.6 COEFF.OF DETERMINATION AND PREDICTIVE RELEVANCE OF ENDOGENOUS LATENT VARIABLES -102-

CHAPTER 4

TABLE 4.1. LITERATURE REVIEW COMPARISON OF CONSUMER SELF-REPORTING SURVEYS -117-
TABLE 4.2 SOCIO DEMOGRAPHIC CHARACTERISTICS OF THE SAMPLE PER TREATMENT, CHI-SQUARE TEST -123-
TABLE 4.3 THROWING ABOVE OR BELOW THE AVERAGE AMERICAN, ANOVA TEST -124-
TABLE 4.4 HOUSEHOLD FOOD WASTE PER TREATMENT IN FOOD IN GENERAL -125-
TABLE 4.5 VOLUME EQUIVALENT (IN GRAMS) AND ANOVA POST-HOC TEST IN FOOD IN GENERAL -125-
TABLE 4.6 HOUSEHOLD FOOD WASTE PER TREATMENT PER FOOD CATEGORIES -127-
TABLE 4.7 VOLUME EQUIVALENT (IN GRAMS) AND ANOVA POST-HOC TEST PER FOOD CATEGORIES -127-
TABLE 4.8 AVERAGE OF FOOD CATEGORIES SHARES OF SUM OF FOOD CATEGORIES PARTICIPANT'S FOOD -128-
TABLE 4.9 FOOD IN GENERAL AND SUM FOOD CATEGORIES AVERAGE SCORE COMPARED TO LITERATURE -130-
TABLE 4.10 CONVERSION SCENARIOS FROM MONEY, MEAL AND ENVIRONMENT TREATMENT TO VOLUME -131-
TABLE A4.1. SAMPLE CHARACTERISTICS COMPARED TO US AVERAGE -136-

List of figures

CHAPTER 2

FIGURE 2.1 FOOD WASTE SOLUTIONS PRIORITIES -63-
FIGURE 2.2. METHODOLOGICAL FRAMEWORK -65-
FIGURE 2.3. EFFECTIVENESS OF DISSENSUS MEASURES ACCORDING STAKEHOLDER PROFILE -76-

CHAPTER 3

FIGURE 3.1. PREVENTIVE MEASURES ALLOCATED WITHIN THE WASTE HIERARCHY -88-
FIGURE 3.2. FOOD WASTE RECOVERY HIERARCHY -89-
FIGURE 3.3. THEORETICAL FRAMEWORK OF FOOD WASTE PREDICTORS -92-
FIGURE 3.4 FOOD WASTE BEHAVIOUR RESULTS PER SITUATION -96-
FIGURE 3.5 MEASUREMENT AND STRUCTURAL MODEL TO PREDICT CONSUMER FOOD WASTE BEHAVIOUR -102-

CHAPTER 4

FIGURE 4.1. SURVEY STRUCTURE -118-
FIGURE 4.2 RESULTS FROM INFORMATION EFFECT ON COMPARISON TO US AVERAGE PER TREATMENT -124-
FIGURE 4.3 TEST OF T-STATISTIC FOR EVERY SCENARIO TO VOLUME TREAT.FOOD WASTE OF SUM OF CAT. -132-

INTRODUCTION

Evidence exists that the achievement of people basics needs are currently met at expenses of trespassing the biophysical planetary boundaries. Meeting basic human needs for all at a globally sustainable level is a significant challenge (Hajer et al., 2015; O'Neill et al., 2018; Raworth, 2017; Rockström et al., 2009). Food systems play a key role on it by allowing both over-consumption of unhealthy food, and extreme poverty at the expense of the resilience of the earth (Foley et al., 2011; P. C. West et al., 2014).

One critical unethical, unsustainable, and uneconomic outcome of the food systems is food waste generation (Kosseva, 2013; Stuart, 2009; Thyberg and Tonjes, 2016). According to the Food and Agricultural Organizations of the United Nations (FAO), one-third of food is lost or wasted worldwide every year (Gustavsson et al., 2011). Meanwhile, eight hundred million of people worldwide are food insecure (FAO et al., 2015) and two billion of people suffer from hidden hunger (lack of micronutrients) (Biodiversity International, 2014). Wasting food entails wasting all the resources necessary to its production, transformation and distribution; also contributing to the damage of ecosystems (GHG, soil degradation, loss of biodiversity)(Sik, 2013; P. C. West et al., 2014). Moreover, food waste has negative economic consequences through the entire food supply chain (Buzby and Hyman, 2012; Campoy-Muñoz et al., 2017; Vogliano and Brown, 2016).

Food waste occurs along the food supply chain, from farm to fork. According to FAO's global estimates food waste at the agriculture stage represents the 35% of the total food loss and waste along the food supply chain, consumers represent another 35%, harvesting 10%, processing 13%, and distribution the remaining 7% (Gustavsson et al., 2011). Globally, 54% of food loss and waste occurs at the beginning of the food supply chain (agricultural production and wholesaling), while 46% takes place downstream (processing, distribution and consumption). The volume and the contribution of each stage to it differ from region to region. North America & Oceania, and Europe are the two regions with the highest food waste rates per capita - approximately 300-340 kg per person per year (Gustavsson et al., 2011). In the Western countries, the primary volume of food waste is located at the consumption stage (Bio Intelligence Service, 2010b; Gustavsson et al., 2011; Katajajuuri et al., 2014; Stenmarck et al., 2016). For instance, according to the FAO's report, 175 kg/pers./year out of the 300 kg of food waste takes place at the household level (Gustavsson et al., 2011). In the same line, a European-centred study quantified in 173 kg/pers./year the food waste along the food supply chain, from which 53% corresponds to households food waste (Stenmarck et al., 2016). In the United States, according to Buzby et al., (2014), the 31% of food at the retail and the consumer level is lost and wasted (133 billion pounds, in 2010).

All these figures are the best available estimates. The full picture of the real generation of food waste is still unknown, although there is burgeoning literature trying to provide more accurate numbers (Bellemare et al., 2017a; Xue et al., 2017). Despite the number of inconsistencies about the volume of food waste, the enormous magnitude of the issue cannot be neglected. Many international institutions have addressed their attention to food waste prevention and reduction during the last decade. In the Rio +20 conference (2012) there was an explicit recognition of the necessity to significantly reduce post-harvest and other food losses and waste throughout the food supply chain (UNCSD, 2012). Lately, in 2015, the Sustainable Development Goals (SDG's) of the United Nations included a specific target (12.3) within the twelfth objective "Ensure sustainable consumption and production patterns" to halve food waste by 2030 (United Nations, 2015). Also, the European Parliament called for practical measures to reduce food waste by 50% by 2025 in the Resolution 2011/2175(INI) (European Parliament, 2012). More recently, the Circular Economy package devoted a pivotal role to food waste measurement and prevention (European Commission, 2018).

In parallel to the increasing concern within the international organizations, the academic research has also experienced a growing interest in the food waste debate. During the last decade, research on food waste has steadily increased (Xue et al., 2017). Researchers from different fields have addressed the phenomenon contributing to quantifying the volumes of food waste (e.g., Beretta et al., 2013; Buzby and Hyman, 2012; Chaboud, 2017; Ju et al., 2017; Willersinn et al., 2015), estimating their associated impacts (e.g., Beretta et al., 2013; Brancoli et al., 2017; Campoy-Muñoz et al., 2017; Mattsson et al., 2018), exploring the food waste drivers (e.g., Canali et al., 2017a; Göbel et al., 2015; Parizeau et al., 2015; Thyberg and Tonjes, 2016), discussing the possible solutions (e.g., Mourad, 2016; Priefer et al., 2016; Strotmann et al., 2017; Thyberg and Tonjes, 2016), and more specially exploring consumers behaviours (e.g., Abeliotis et al., 2014; Evans, 2011; Porpino et al., 2016; Quested et al., 2013; Stancu et al., 2016).

In any case, the academic literature is very incipient and there is significant room for deepen in all issues mentioned above and to generate new topics and debates around the food waste issue. Two of the most controversial issues nowadays concern the conceptual debates (Bellemare et al., 2017a; Chaboud, 2017; HLPE, 2014) and the methodologies to estimate food waste volume (Bellemare et al., 2017; Bräutigam et al., 2014; Xue et al., 2017), which, on the other hand, are related to each other. Moreover, in spite of the increasing literature on food waste, most studies approach the problem partially (i.e. only one level of the food supply chain), and there is a clear missing of first-hand data collection.

Recent publications and leading organisations highlight the complex nature of the food waste phenomenon (Abiad and Meho, 2018; Campbell et al., 2017; GIZ et al., 2016; HLPE, 2014;

Montagut and Gascón, 2014; Muriana, 2017; Papargyropoulou et al., 2016, 2014). Holistic approaches, considering the whole supply and engaging different stakeholders are of highly importance and relevance. In this line, we have identified two main gaps on the literature, 1) considering the whole supply chain to understand and propose solutions to food waste generation, and 2) examining consumer food waste behaviour in a multidimensional and critical perspective.

Whole supply chain approaches and stakeholder engagement

Stage-centred studies on food waste are useful to thoroughly understand the particularities of that stage or a specific type of stakeholders as regards as food waste generation. However, the complexity of the phenomenon would require systemic approaches to in-depth address it. Food waste volumes at a specific stage of the food supply chain are not necessarily a consequence of stakeholders' behaviour at such stage (HLPE, 2014).). Responsibilities on food waste generation are spread along the whole food supply chain and, in some cases, the cause-effect is not immediate. The majority of the studies on food waste only consider one stage of the food supply chain: the farm level (e.g., Beausang et al., 2017; Paper et al., 2014), the food industries (e.g., Garrone et al., 2014; Mena et al., 2011; Strotmann et al., 2017), the retail (e.g., Brancoli et al., 2017; Cicatiello et al., 2017; Mena et al., 2011b), the food service (e.g., Derqui et al., 2018; Falasconi et al., 2015; Roe et al., 2018), or the households (e.g., Neff et al., 2015; Qi and Roe, 2016; Setti et al., 2016). Only a few are dealing with multiple stages and topics related to food waste at the same time (e.g., Canali et al., 2017; Göbel et al., 2015; Katajajuuri et al., 2014). Further research is needed to fully understand the causes and potential solutions to food waste taking into account the complexity of food systems.

The second limitation of previous studies is the lack of stakeholders' engagement, who, we consider, can provide relevant first-hand information (Xue et al., 2017). Previous research demonstrated the importance of including different stakeholders in the study of complex environmental and social issues to face them more effectively (Faysse et al., 2014; Li et al., 2017; Perveen et al., 2017; Reed, 2008). Moreover, this is aligned with the Århus Convention (signed by the European Community and its Member States in 1998 (2005/370/EC)), which promotes the "the rights of access to information, public participation in decision-making, and access to justice in environmental matters"[1] *(European Union, 2005)*. In the case of food waste, debates have been kept on scientific experts and high-level policy bodies. Collaborative networks between scientific actors, European authorities, local authorities and citizens are needed to tackle food waste. There is a need to open the debate and engage all stakeholders involved in the food system.

Multidimensional and critical perspectives on consumer understanding

[1] http://europa.eu/legislation_summaries/environment/general_provisions/l28056_es.htm

Food waste is acknowledged to be (at least) a social, an economic and an environmental threat (Gustavsson et al., 2011; HLPE, 2014; Stuart, 2009; Thyberg and Tonjes, 2016), but it can also be considered from multiple dimensions regarding the use of resources, the waste management, the food and diet, the food security, and so forth. A huge variety of policies and regulations can influence food waste generation (European Union, 2016). However, consumer studies on food waste behaviour tend to focus their interest in a single dimension (food-related behaviour, waste-related behaviour or psychological factors) but do not incorporate the multi-dimensionality mentioned above. There are increasing evidences showing the complex character of consumers' food waste (Evans, 2011; Porpino et al., 2015) and arriving at the conclusion that food waste is not a rational behaviour that can be easily predicted since multiple factors play an important role (lifestyle, social pressure, values, knowledge, and so forth). More research is needed in this line to understand better consumers' food waste behaviour and to help policymakers to design genuine prevention and reduction of food waste campaigns.

Moreover, despite published data revealed that that consumption stage is the major contributor to food waste volume (Bio Intelligence Service, 2010b; Gustavsson et al., 2011; Katajajuuri et al., 2014; Stenmarck et al., 2016), there is plenty of inconsistencies on the published numbers (Bellemare et al., 2017a; Xue et al., 2017). Consumer food waste is difficult to measure (FUSIONS, 2014a; Roodhuyzen et al., 2017; Thyberg and Tonjes, 2016; Xue et al., 2017) and further research is needed to improve the knowledge of the situation.

Objectives

The primary objective of this thesis is to explore and explain the factors influencing the food waste generation and to explore potential measures to prevent and reduce the current generation at different levels of the supply chain. To achieve this objective, this thesis is structured into two main parts. The first one considers the whole food supply chain while the second focusses at the household level. The specific objectives of the thesis are:

1) To analyse the causes of food waste generation and its circumstantial or structural nature along the food supply chain.
2) To identify and prioritize food waste prevention and reduction measures along the food supply chain.
3) To better understand consumer food waste behaviour by considering a multidimensional model.
4) To critically analyse in-home consumer food waste measurement and the effect of framing and information on consumers' perception of food waste generation.

Thesis structure

The thesis is structured in four chapter that covers two food waste dimensions or modules. First, the whole-supply module responds to the first two specific objectives. Second, the consumer module tackles with the third and fourth specific objectives. There is a combination of quantitative and qualitative methods to collect first-hand data in each chapter.

The first module seeks to contribute to the general objective with a holistic approach by having into account multiple stages, multiple types of stakeholders at the regional level, the metropolitan region of Barcelona. It is divided into two independent chapters:

The **first chapter** addresses two specific objectives: 1) identify the causes of food waste in the studied region, and 2) examine the circumstantial or structural nature of the causes of food waste identified. In-depth interviews with key stakeholders in the region were implemented. The results of the interviews were analysed using content analysis and a conceptual framework based on previous publications.

The **second chapter** is focused on finding out solutions to food waste generation. It has two specific objectives: 1) identify and prioritize measures to switch the current scenario to prevent and reduce the food waste generation along the food supply chain and 2) examine the role of different stakeholders on food waste prevention and reduction. To do so, a two-stage methodological approach was implemented. The first stage was explorative, in-depth interviews with key stakeholders in the region (same as in chapter 1). The second stage was deliberative, it consisted of a Delphi survey to evaluate the effectiveness of proposed solutions in the first stage to prevent and reduce food waste. The results are discussed taking into account previous literature as well as the hierarchy of food waste management.

The consumers understanding module seeks to contribute to the overall objective by analysing consumers' food waste perception and behaviour with a critical and holistic perspective. This part is structured into two chapters each of them corresponding to two case studies: the first one in the metropolitan region and Barcelona and the second one in the United States.

The **third chapter** of the thesis is addressing two specific objectives: 1) provide a better understanding of consumers' food waste behaviour at the household level and 2) validate a multidimensional theoretical model of consumer food waste generation. A conceptual model based on previous literature is tested. An auto-administrated survey of consumers in the metropolitan region of Barcelona was implemented. The model was statistically validated through Partial Least Squares Equation Modelling.

The **fourth chapter** of the thesis is aimed at determining how people respond to different frames used in waste reduction campaigns. A secondary objective is to measure household food

waste generation utilizing a self-reporting survey. A survey experiment method was employed to consumers in the United States. The results show and discuss the effect of framing on food waste generation in-home and its policy and research implications.

Food waste definition

There is neither an official definition of food waste nor a definition generating large consensus on the food waste debate; multiple interpretations coexist nowadays. Evidencing that the food waste domain is not only an emerging issue but also a highly controversial concept. Since FAO used the concept of food loss and waste in 1981, its conceptual framework has been continuously changing up to 2014 incorporating new concepts and definitions during all this time. In Europe, there has been an in-depth debate during the last years to find out an official definition.

Only comparing two relevant definitions such as the latest FAO's (FAO, 2014) and the FUSIONS FP7 project of the European Commission (FUSIONS, 2014b) can be observed multiple variations. They both pursue different initial aims. While FAO`s definition is related to food security issue, the latter derives from using resources efficiency (Chaboud and Daviron 2017).

FAO definition 2014 (FAO, 2014)**:**

- ***Food loss:*** "a decrease in mass (dry matter) or nutritional value (quality) of food that was originally intended for human consumption."
- ***Food waste:*** "food appropriate for human consumption being discarded, whether or not after it is kept beyond its expiry date or left to spoil. "
- ***Food wastage:*** "any food lost by deterioration or waste. Thus, the term "wastage" encompasses both food loss and food waste."

FUSIONS definition (FUSIONS, 2014b)**:**

- ***Food waste:*** *"*is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea"

The European Parliament has very recently included an official definition of "food waste" on the Directive (EU) 2018/851 of the European Parliament and of the Council of 30 of May 2018 amending the Directive 2008/98/EC on waste.

- ***Food waste:*** "means all food as defined in Article 2 of Regulation (EC) No 178/2002 of the European Parliament and of the Council that has become waste"

Some international institutions are dealing with the discrepancies of food waste definitions not including any within their reports and protocols. For instance, the international Food Loss & Waste Protocol from the Word Resources Institute, as a result of these difficulties and the existing discrepancies, does not include a definition of food waste and keeps it flexible (World Resources Institute, 2016). Likewise, the 12.3 target of SDG's on food waste and loss does not include, yet, a specific definition (United Nations, 2015).

This thesis does not embrace any specific food waste definition or terminology. A generic term "food waste" is used in all four chapters to address the objectives. During data collection, different discourses and terminology were found. On the whole-supply chapters, direct interviews with stakeholders allowed flexibility to discuss with them in a broad sense. Within consumers' surveys, no specific concept of "food waste" was used. Instead, questions referred in a general manner to "food thrown away".

References

Abeliotis, K., Lasaridi, K., Chroni, C., 2014. Attitudes and behaviour of Greek households regarding food waste prevention. Waste Manag. Res. 32, 237–40. doi:10.1177/0734242X14521681

Abiad, M.G., Meho, L.I., 2018. Food loss and food waste research in the Arab world: a systematic review. Food Secur. 10, 311–322. doi:10.1007/s12571-018-0782-7

Beausang, C., Hall, C., Toma, L., 2017. Food waste and losses in primary production: Qualitative insights from horticulture. Resour. Conserv. Recycl. 126, 177–185. doi:10.1016/J.RESCONREC.2017.07.042

Bellemare, M.F., Çakir, M., Peterson, H.H., Novak, L., Rudi, J., 2017a. On the Measurement of Food Waste. Am. J. Agric. Econ. 99, 1148–1158. doi:10.1093/ajae/aax034

Bellemare, M.F., Çakir, M., Peterson, H.H., Novak, L., Rudi, J., 2017b. On the Measurement of Food Waste. Waste Manag. 28, 3–10. doi:10.1016/j.wasman.2018.01.014

Beretta, C., Stoessel, F., Baier, U., Hellweg, S., 2013. Quantifying food losses and the potential for reduction in Switzerland. Waste Manag. 33, 764–773. doi:10.1016/j.wasman.2012.11.007

Bio Intelligence Service, 2010. Preparatory Study on Food Waste Across EU 27. doi:10.2779/85947

Biodiversity International, 2014. Bioversity International's 10-year strategy 2014-2024. doi:ISBN: 978-92-9043-992-9

Brancoli, P., Rousta, K., Bolton, K., 2017. Life cycle assessment of supermarket food waste. Resour. Conserv. Recycl. 118, 39–46. doi:10.1016/j.resconrec.2016.11.024

Bräutigam, K.-R.R., Jörissen, J., Priefer, C., 2014. The extent of food waste generation across EU-27: Different calculation methods and the reliability of their results. Waste Manag. Res. 32, 683–694. doi:10.1177/0734242X14545374

Buzby, J.C., Hyman, J., 2012. Total and per capita value of food loss in the United States. Food Policy 37, 561–570. doi:10.1016/j.foodpol.2012.06.002

Buzby, J.C., Wells, H.F., Hyman, J., 2014. The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States. Econ. Inf. Bull. 39.

Campbell, H., Evans, D., Murcott, A., 2017. Measurability, austerity and edibility: Introducing waste into food regime theory. J. Rural Stud. 51, 168–177. doi:10.1016/j.jrurstud.2017.01.017

Campoy-Muñoz, P., Cardenete, M.A., Delgado, M.C., 2017. Economic impact assessment of food waste reduction on European countries through social accounting matrices. Resour. Conserv. Recycl. 122, 202–209. doi:10.1016/j.resconrec.2017.02.010

Canali, M., Amani, P., Aramyan, L., Gheoldus, M., Moates, G., Östergren, K., Silvennoinen, K., Waldron, K., Vittuari, M., 2017. Food waste drivers in Europe, from identification to possible interventions. Sustain. 9, 37. doi:10.3390/su9010037

Chaboud, G., 2017. Assessing food losses and waste with a methodological framework: Insights from a case study. Resour. Conserv. Recycl. 125, 188–197. doi:10.1016/j.resconrec.2017.06.008

Chaboud, G., Daviron, B., 2017. Food losses and waste: Navigating the inconsistencies. Glob. Food Sec. 12, 1–7. doi:10.1016/j.gfs.2016.11.004

Cicatiello, C., Franco, S., Pancino, B., Blasi, E., Falasconi, L., 2017. The dark side of retail food waste: Evidences from in-store data. Resour. Conserv. Recycl. 125, 273–281. doi:10.1016/j.resconrec.2017.06.010

Derqui, B., Fernandez, V., Fayos, T., 2018. Towards more sustainable food systems. Addressing food waste at school canteens. Appetite 129, 1–11. doi:10.1016/J.APPET.2018.06.022

European Commission, 2018. A monitoring framework for the circular economy, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committe of the Regions.

European Parliament, 2012. Avoiding food wastage. O, European Parliament resolution of 19 January 2012 Wastage:, n how to avoid food E, strategies for a more efficient food chain in the (2011/2175(INI)).

European Union, 2016. Combating Food Waste: an opportunity for the EU to improve the resource-efficiency of the food supply chain. Special report NO 34 (EN). European Court of Auditors (ECA) - European Union. doi:10.2865/8374

European Union, 2005. COUNCIL DECISION of 17 February 2005 on the conclusion, on behalf of the European Community, of the Convention on access to information, public participation in decision-making and access to justice in environmental matters 2005/370/EC. Official Journal of the European Union.

Evans, D., 2011. Blaming the consumer – once again: the social and material contexts of everyday food waste practices in some English households. Crit. Public Health 21, 429–440. doi:10.1080/09581596.2011.608797

Falasconi, L., Vittuari, M., Politano, A., Segrè, A., 2015. Food waste in school catering: An Italian case study. Sustain. 7, 14745–14760. doi:10.3390/su71114745

FAO, 2014. Save Food: Global Initiative on Food Loss and Waste Reduction. Definitional framework of food loss.

FAO, IFAD, WFP., 2015. The State of Food Insecurity in the World: Meeting the 2015 international hunger targets: taking stock of uneven progress., FAO, IFAD and WFP. doi:I4646E/1/05.15

Faysse, N., Rinaudo, J.-D., Bento, S., Richard-Ferroudji, A., Errahj, M., Varanda, M., Imache, A., Dionnet, M., Rollin, D., Garin, P., Kuper, M., Maton, L., Montginoul, M., 2014. Participatory analysis for adaptation to climate change in Mediterranean agricultural systems: possible choices in process design. Reg. Environ. Chang. 14, 57–70. doi:10.1007/s10113-012-0362-x

Foley, J.A., Ramankutty, N., Brauman, K.A., Cassidy, E.S., Gerber, J.S., Johnston, M., Mueller, N.D., O'Connell, C., Ray, D.K., West, P.C., Balzer, C., Bennett, E.M., Carpenter, S.R., Hill, J., Monfreda, C., Polasky, S., Rockström, J., Sheehan, J., Siebert, S., Tilman, D., Zaks, D.P.M., 2011. Solutions for a cultivated planet. Nature 478, 337–342. doi:10.1038/nature10452

FUSIONS, 2015. FUSIONS food waste data set for EU-28. FUSIONS EU Proj.

FUSIONS, 2014a. Standard approach on quantitative techniques to be used to estimate food waste levels.

FUSIONS, 2014b. FUSIONS Definitional Framework for Food Waste Full report.

Garrone, P., Melacini, M., Perego, A., 2014. Opening the black box of food waste reduction. Food Policy 46, 129–139. doi:10.1016/j.foodpol.2014.03.014

GIZ, FAO, RUAF, 2016. City Region Food Systems and Food Waste Management.

Göbel, C., Langen, N., Blumenthal, A., Teitscheid, P., Ritter, G., 2015. Cutting Food Waste through Cooperation along the Food Supply Chain. Sustainability 7, 1429–1445. doi:10.3390/su7021429

Gustavsson, J., Cedeberg, C., Sonesson, U., Otterdijk, R. van, Meybeck, A., 2011. Global food losses and food waste - Extent, causes and prevention. Rome.

Hajer, M., Nilsson, M., Raworth, K., Bakker, P., Berkhout, F., de Boer, Y., Rockström, J., Ludwig, K., Kok, M., 2015. Beyond Cockpit-ism: Four Insights to Enhance the Transformative Potential of the Sustainable Development Goals. Sustainability 7, 1651–1660. doi:10.3390/su7021651

HLPE, 2014. Food losses and waste in the context of sustainable food systems. A Rep. by High Lev. Panel Expert. Food Secur. Nutr. Comm. World Food Secur. Rome 2014.

Ju, M., Osako, M., Harashina, S., 2017. Food loss rate in food supply chain using material flow analysis. Waste Manag. 61, 443–454. doi:10.1016/j.wasman.2017.01.021

Katajajuuri, J.-M., Silvennoinen, K., Hartikainen, H., Heikkilä, L., Reinikainen, A., 2014. Food waste in the Finnish food chain. J. Clean. Prod. 73, 322–329. doi:10.1016/j.jclepro.2013.12.057

Kosseva, M.R., 2013. Introduction: Causes and Challenges of Food Wastage, in: Food Industry Wastes. Assessment and Recuperation of Commodities. Elsevier, pp. xv–xxiv. doi:10.1016/B978-0-12-391921-2.00019-6

Li, L., Yuan, J., Roper, K., Zhou, Z., 2017. A Multi-Stakeholder Delphi Study to Determine Key Space Management Components for Elderly Facilities in China. Sustainability 9, 1565. doi:10.3390/su9091565

Mattsson, L., Williams, H., Berghel, J., 2018. Waste of fresh fruit and vegetables at retailers in Sweden – Measuring and calculation of mass, economic cost and climate impact. Resour. Conserv. Recycl. 130, 118–126. doi:10.1016/j.resconrec.2017.10.037

Mena, C., Adenso-Diaz, B., Yurt, O., 2011a. The causes of food waste in the supplier–retailer interface: Evidences from the UK and Spain. Resour. Conserv. Recycl. 55, 648–658. doi:10.1016/j.resconrec.2010.09.006

Mena, C., Adenso-Diaz, B., Yurt, O., 2011b. The causes of food waste in the supplier-retailer interface: Evidences from the UK and Spain. Resour. Conserv. Recycl. 55, 648–658. doi:10.1016/j.resconrec.2010.09.006

Montagut, X., Gascón, J., 2014. Alimentos desperdiciados. Barcelona; Quito.

Mourad, M., 2016. Recycling, recovering and preventing "food waste": competing solutions for food systems sustainability in the United States and France. J. Clean. Prod. 126, 461–477. doi:10.1016/j.jclepro.2016.03.084

Muriana, C., 2017. A focus on the state of the art of food waste/losses issue and suggestions for future researches. Waste Manag. 68, 557–570. doi:10.1016/j.wasman.2017.06.047

Neff, R. a., Spiker, M.L., Truant, P.L., 2015. Wasted Food: U.S. Consumers' Reported Awareness, Attitudes, and Behaviors. PLoS One 10, e0127881. doi:10.1371/journal.pone.0127881

O'Neill, D.W., Fanning, A.L., Lamb, W.F., Steinberger, J.K., 2018. A good life for all within planetary boundaries. Nat. Sustain. 1, 88–95. doi:10.1038/s41893-018-0021-4

Papargyropoulou, E., Lozano, R., Steinberger, J., Wright, N., Ujang, Z. Bin, K. Steinberger, J., Wright, N., Ujang, Z. Bin, Steinberger, J., Wright, N., Ujang, Z. Bin, 2014. The food waste hierarchy as a framework for the management of food surplus and food waste. J. Clean. Prod. 76, 106–115. doi:10.1016/j.jclepro.2014.04.020

Papargyropoulou, E., Wright, N., Lozano, R., Steinberger, J., Padfield, R., Ujang, Z., 2016. Conceptual framework for the study of food waste generation and prevention in the hospitality sector. Waste Manag. 49, 326–336. doi:10.1016/j.wasman.2016.01.017

Paper, W., Do, W., Say, F., 2014. Post-Harvest Loss in Sub-Saharan Africa What Do Farmers Say ? Glob. Food Sec. 3, 149–158. doi:10.1016/j.gfs.2014.10.002

Parizeau, K., Massow, M. von, Martin, R., 2015. Household-level dynamics of food waste production and related beliefs, attitudes, and behaviours in Guelph, Ontario. Waste Manag. 35, 207–217. doi:10.1016/j.wasman.2014.09.019

Perveen, S., Kamruzzaman, M., Yigitcanlar, T., 2017. Developing policy scenarios for sustainable urban growth management: A Delphi approach. Sustain. 9, 1787. doi:10.3390/su9101787

Porpino, G., Parente, J., Wansink, B., 2015. Food waste paradox: antecedents of food disposal in low income households. Int. J. Consum. Stud. 39, 619–629. doi:10.1111/ijcs.12207

Porpino, G., Wansink, B., Parente, J.G., 2016. Wasted Positive Intentions: The Role of Affection and Abundance on Household Food Waste. J. Food Prod. Mark. 4446, Forthcoming. doi:10.1080/10454446.2015.1121433

Priefer, C., Jörissen, J., Bräutigam, K.-R., 2016. Food waste prevention in Europe - A cause-driven approach to identify the most relevant leverage points for action. Resour. Conserv. Recycl. 109, 155–165. doi:10.1016/j.resconrec.2016.03.004

Qi, D., Roe, B.E., 2016. Household food waste: Multivariate regression and principal components analyses of awareness and attitudes among u.s. consumers. PLoS One 11, 1–19. doi:10.1371/journal.pone.0159250

Quested, T.E., Marsh, E., Stunell, D., Parry, A.D., 2013. Spaghetti soup: The complex world of food waste behaviours. Resour. Conserv. Recycl. 79, 43–51. doi:10.1016/j.resconrec.2013.04.011

Raworth, K., 2017. Doughnut economics : seven ways to think like a 21st-century economist.

Reed, M.S., 2008. Stakeholder participation for environmental management: A literature review. Biol. Conserv. 141, 2417–2431. doi:10.1016/J.BIOCON.2008.07.014

Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P., Foley, J.A., 2009. A safe operating space for humanity. Nature 461, 472–475. doi:10.1038/461472a

Roe, B.E., Apolzan, J.W., Qi, D., Allen, H.R., Martin, C.K., 2018. Plate waste of adults in the United States measured in free-living conditions. PLoS One 13, 1–16. doi:10.1371/journal.pone.0191813

Roodhuyzen, D.M.A., Luning, P.A., Fogliano, V., Steenbekkers, L.P.A., 2017. Putting together the puzzle of consumer food waste: Towards an integral perspective. Trends Food Sci. Technol. 68, 37–50. doi:10.1016/j.tifs.2017.07.009

Setti, M., Falasconi, L., Segrè, A., Cusano, I., Vittuari, M., 2016. Italian consumers' income and food waste behavior. Br. Food J. Iss Br. Food J. Br. Food J. Br. Food J. 118, 1731–1746. doi:10.1108/02656710210415703

Sik, B., 2013. The methodology of the FAO study : " Global Food Losses and Food Waste - extent , causes and prevention " - FAO , 2011 By SIK - The Swedish Institute for Food and Biotechnology.

Stancu, V., Haugaard, P., Lähteenmäki, L., 2016. Determinants of consumer food waste behaviour: Two routes to food waste. Appetite 96, 7–17. doi:10.1016/j.appet.2015.08.025

Stenmarck, Å., Jensen, C., Quested, T., Moates, G., 2016. Estimates of European food waste levels.

Strotmann, C., Göbel, C., Friedrich, S., Kreyenschmidt, J., Ritter, G., Teitscheid, P., Gï¿½bel, C., Friedrich, S., Kreyenschmidt, J., Ritter, G., Teitscheid, P., 2017. A participatory approach to minimizing food waste in the food industry-A manual for managers. Sustain. 9, 1–21. doi:10.3390/su9010066

Stuart, T., 2009. Waste: Uncovering the Global Food Scandal. Penguin books, London.

Thyberg, K.L., Tonjes, D.J., 2016. Drivers of food waste and their implications for sustainable policy development. Resour. Conserv. Recycl. 106, 110–123. doi:10.1016/j.resconrec.2015.11.016

UNCSD, 2012. Resolution adopted by the General Assembly on 27 July 2012 66/288. The future we want.

United Nations, 2015. Transforming our world: the 2030 Agenda for Sustainable Development, General Assembley 70 session. doi:10.1007/s13398-014-0173-7.2

Vogliano, C., Brown, K., 2016. The State of America's Wasted Food and Opportunities to Make a Difference. J. Acad. Nutr. Diet. 116, 1199–1207. doi:10.1016/j.jand.2016.01.022

West, P.C., Gerber, J.S., Engstrom, P.M., Mueller, N.D., Brauman, K.A., Carlson, K.M., Cassidy, E.S., Johnston, M., MacDonald, G.K., Ray, D.K., Siebert, S., 2014. Leverage points for improving global food security and the environment. Science (80-.). 345, 325–328. doi:10.1126/science.1246067

Willersinn, C., Mack, G., Mouron, P., Keiser, A., Siegrist, M., 2015. Quantity and quality of food losses along the Swiss potato supply chain: Stepwise investigation and the influence of quality standards on losses. Waste Manag. 46, 120–132. doi:10.1016/j.wasman.2015.08.033

World Resources Institute, 2016. Food Loss and Waste Accounting and Reporting Standard 160.

Xue, L., Liu, G., Parfitt, J., Liu, X., Van Herpen, E., Stenmarck, Å., O'Connor, C., Östergren, K., Cheng, S., 2017. Missing Food, Missing Data? A Critical Review of Global Food Losses and Food Waste Data. Environ. Sci. Technol. 51, 6618–6633. doi:10.1021/acs.est.7b00401

CHAPTER 1

A Sum of incidentals or a structural problem? The true nature of food waste in the metropolitan region of Barcelona

This paper has been accepted to be published in:

Diaz-Ruiz, R., Costa-Font, M., López-i-Gelats, F., Gil, J.M. (in press) "A Sum of Incidentals or a Structural Problem? The True Nature of Food Waste in the Metropolitan Region of Barcelona*" Sustainability*

A preliminary version of this paper was presented in a Spanish Congress in September 2015:

Díaz-Ruiz, R., Costa-Font, M., Gil, J.M., López-i-Gelats, F. ***El desperdicio alimentario ¿un problema estructural o coyuntural? Identificación de los factores que lo determinan.*** *Presented in X Congreso de la asociación española de economía agrària. Alimentación y Territorios sos tenibles desde el Sur de Europa, 9-11 de septiembre de 2015, Córdoba, Spain*

1.1.Introduction

Finding alternatives to develop more sustainable food systems is a major challenge that society is facing today. Multiple efforts are being devoted to better understand such food systems and, consequently, to develop more sustainable alternatives (e.g., Gamboa et al., 2016; IPES-Food, 2016; Vivero-Pol, 2017; Paul C West et al., 2014). In this context, food waste has emerged as one of the most relevant domains of the current unsustainability (GIZ et al., 2016). The estimates of the Food and Agricultural Organization of the United Nations (FAO) suggest that one-third of the food produced globally is being lost or wasted along the food supply chain (Gustavsson et al., 2011). In Europe, a recent estimation has indicated that 88 million tons of food are wasted annually (Stenmarck et al., 2016). The magnitude of the numbers has fostered a wide and growing agreement regarding the necessity of urgently addressing the issue of food waste generation. The United Nations agreed in 2015, within the definition of the Sustainable Development Goals, to halve food waste and reduce food losses by 2030 (United Nations, 2015). In Europe, the European Union's recently approved Circular Economy Package has allocated a key role to food waste prevention and reduction (European Commission, 2018).

The increasing awareness of the importance of the food waste challenge has grown in parallel with the number of publications devoted to better understanding this phenomenon, especially during the last decade (Xue et al., 2017), and such publications have been particularly focused on the consumption stage (Schanes et al., 2018). The research on food waste has been diverse. To date, the relevant publications have mainly been focused on understanding consumer behavior (e.g., Evans, 2011; Mondéjar-Jiménez et al., 2015; Porpino et al., 2016; Roodhuyzen et al., 2017) or quantifying the generated volume of food waste (e.g., Buzby and Hyman, 2012; Katajajuuri et al., 2014; Redlingshöfer et al., 2017) and its associated environmental or economic impact (e.g., Beretta et al., 2017; Buzby and Hyman, 2012; De Menna et al., 2018; Heller and Keoleian, 2014). However, there is still considerable room for advancement. Numerous gaps still prevail concerning the underlying factors of food waste generation (HLPE, 2014; Xue et al., 2017). Despite efforts to standardize food waste quantifications (e.g., the Food Loss and Waste Protocol (World Resources Institute, 2016)) and the FUSIONS[2] protocol (FUSIONS, 2016), there is still no single agreed-upon definition of food waste, neither internationally nor in Europe (Bellemare et al., 2017a; Chaboud, 2017; HLPE, 2014). The discrepancies in the more adequate methodologies for undertaking the sound quantification of food waste make it difficult to compare results from different studies (Bellemare et al., 2017a; Bräutigam et al., 2014; Xue et al., 2017). The complexity of the phenomenon suggests the necessity of taking a step back and examining what are the roots of the food waste phenomenon.

[2]Food Use for Social Innovation by Optimising Waste Prevention Strategies

Despite the rapidly increasing body of literature dealing with the food waste issue, only a few studies have attempted to focus on analyzing where the roots of the problem lie, that is, the causes of the phenomenon. A great diversity of studies, ad hoc reports, papers, and books has been published in the last decade (see Table 1.1.). They fundamentally employed secondary data to identify the causes of food waste at different geographical scales, ranging from worldwide to regional levels of analysis. Most of these studies used a partial view approach, that is, they included in the analysis only specific stages of the supply chain. On the other hand, those considering all the stages of the food supply chain dealt with secondary data. To our knowledge, there is only one study—by Göbel et al., (2015)—that has used primary data—collected by means of expert interviews along the whole food supply chain in the region of North Rhine-Westphalia in Germany—to examine the causes of food waste using whole-supply-chain analysis.

Table 1.1. Food waste cause-analysis studies

References	Type of document	Type of data*	Geographical scope	Farm	Industry	Wholesale	Distribution	Consumption
WRAP et al., 2007	Report	1	United Kingdom (UK)					●
WRAP and Quested, 2009	Report	2	UK					●
Stuart, 2009	Book	2	Worldwide					●
Parfitt et al., 2010	Paper	2	Worldwide	●	●		●	●
Bio Intelligence Service, 2010	Report	2	Europe		●		●	●
Mena et al., 2011	Paper	1	UK and Spain	●			●	
HISPACOOP, 2012	Report	1	Spain					●
ARC and UAB, 2011	Report	1+2	Catalonia, Spain				●	●
Buzby and Hyman, 2012	Paper	2	United States	●	●		●	●
Beretta et al., 2013	Paper	1	Switzerland	●			●	
European Union, 2013	Report	2	Europe					●
Stefan et al., 2013	Paper	1	Romania					●
FAO, 2013	Report	1+2	World	●	●		●	
Garrone et al., 2014	Paper	1	Italy	●	●			
Magrama, 2014a	Report	1	Spain	●				
Magrama, 2014b	Report	1	Spain				●	
Magrama, 2014c	Report	1	Spain		●			
Mena et al., 2014	Paper	1	UK	●	●		●	
HLPE, 2014b	Report	2	Worldwide	●	●	●	●	●
Montagut and Gascón, 2014	Book	2	Worldwide	●				
Parizeau et al., 2015a	Paper	1	Guelph, Ontario, Canada					●
Göbel et al., 2015	Paper	1	North Rhine-Westphalia, Germany	●	●	●	●	●
Derqui et al., 2016	paper	1	Spain					●
Thyberg and Tonjes, 2016	Paper	2	Worldwide	●	●	●	●	●
Canali et al., 2017	Paper	2	Worldwide	●	●	●	●	●
Hebrok and Boks, 2017	Paper	2	Worldwide					●

Note: * 1 means primary data, and 2 means secondary data.

As shown in Table 1.1., the great majority of the existing works dealing with the causes of food waste examine the issue partially. Thus, there is a need to implement approaches suited to better capture the inherent complexity of the food waste dynamics. In this context, there is also a

growing concern among the leading organizations about the importance of implementing multidimensional and whole-supply-chain approaches to more adequately examine the food waste phenomenon (Abiad and Meho, 2018; Campbell et al., 2017; GIZ et al., 2016; HLPE, 2014; Montagut and Gascón, 2014; Muriana, 2017; Papargyropoulou et al., 2016, 2014).

The geographical scope of the analysis is also relevant when addressing food waste. The scale determines the governance of all the agents implicated in the design of alternatives to the identified problems (Mourad, 2016). Global recipes are often disseminated to address food waste at different levels: the international, European, country-specific, regional, or municipal level. Nevertheless, recent evidence has suggested that cultural and regional characteristics could be, to a certain extent, key determinants of food waste generation (Geffen et al., 2016; Raak et al., 2017). In this context, the RUAF[3] Foundation and FAO have advocated for the use of the City Regions Food Systems as an appropriate approach that provides a valuable and useful scope for understanding the food waste occurrence within a food system (Blay-Palmer et al., 2018; GIZ et al., 2016). Moreover, as a result of the Milan Urban Food Urban Pact, food waste has become one of the priority areas for the sustainability of cities (MUFPP, 2017).

Thus, considering both the lack of multidimensional and whole-supply-chain approaches and the key role regions will have to play in the fight against food waste, here, we aimed to fill this void by conducting a holistic analysis of the causes of food waste in a particular region, the metropolitan region of Barcelona. The objective of this work was twofold: first, identifying the causes of food waste in the metropolitan region of Barcelona; and second, examining the circumstantial or structural nature of the causes of the food waste. In doing so, we examined the perceptions of key stakeholders along the food supply chain in the metropolitan region of Barcelona through in-depth interviews. All the interviews were analyzed by content analysis, and the main causes identified by the regional stakeholders were classified according to a specific framework based upon the previous literature.

1.2.The case study: the metropolitan region of Barcelona

The metropolitan region of Barcelona is one of the most populated areas of Europe, located on the Mediterranean coast in the autonomous community of Catalonia, in Spain. It has a population of more than 4.8 million people in an area of 3236 km^2 (Idescat, 2017). The agri-food sector is highly relevant in the metropolitan region through all the stages of the food supply chain. A peri-urban agricultural park is located in the region, with more than 2800 producers (Baix Llobregat Agricultural Park). The land allocated to agricultural production is not very large. Yet, the agricultural park has contributed to preserving the farming sector in the peri-urban

[3] Resource Centres on Urban Agriculture and Food Security

environment (Paül and McKenzie, 2013). The industrial agri-food sector is the second most important economic sector in Catalonia. Multiple national and international food companies' central headquarters are located in the region (Àrea Metropolitana de Barcelona; and Institut Cerdà, 2017). The Barcelona central wholesale market is one of the main food clusters in southwestern Europe. Moreover, Barcelona city is known for its hospitality sector's broad offerings and fresh food local markets. Regarding waste generation, the food industry is the major generator of tons of waste, which represented 25% of the total industrial waste in Catalonia in 2013 (ARC, 2014a). At the municipal level of waste collection, 475 kg of waste per person were quantified in 2013, the main fraction of which was bio-waste (ARC, 2014b).

During recent years, different initiatives to prevent and reduce food waste have been started in Spain. They are largely led by grassroots movements and NGOs (e.g., "*Yo no desperdicio*" (Prosalus, 2016) and *"No tires la comida"* (OCU, 2016)), but also by other different agents, such public bodies (e.g., *"Mas alimento menos desperdicio"* (Magrama, 2013) and *"Som gent de profit"* (ARC, 2016)) and private companies (e.g., *"La alimentación no tiene desperdicio, aprovechala*" (AECOC, 2016)). However, it should be noted that, in Spain, the authority to regulate waste and food has been transferred to the autonomous regions since the 1980s. Consequently, each autonomous region might show a different level of engagement on the food waste challenge. Catalonia concentrates most of the initiatives of food waste prevention and reduction in the metropolitan region,[4] in particular.

In spite of this growing interest, the scientific literature on food waste in Spain is scarce, except for recent publications (e.g., Derqui et al., 2016; González-Torre et al., 2016; Mena et al., 2011). The dissemination of research results has been primarily conducted through outreach documents and reports. In any case, most of the studies have been focused on one single stage of the food supply chain—whether primary production (Magrama, 2014a); the food industry (Magrama, 2014c); the supplier–retailer interface (Mena et al., 2011a); food distribution and food service (Derqui et al., 2016; Magrama, 2014b); or the consumption stage (Geffen et al., 2016; HISPACOOP, 2012; Magrama, 2016). In Catalonia, a specific quantification of food waste from distribution to households was carried out in 2010 (ARC and UAB, 2011). Additionally, most of the studies have used different food waste conceptual frameworks and scopes, if any, which makes it difficult to make comparisons between them or even with other studies abroad. In the metropolitan region of Barcelona, there has been no specific study on food waste, apart from

[4] For more details, see initiatives maps http://aprofitemelsaliments.org/mapa-diniciatives-per-laprofitament/ and Davies, A.R. et al. (2016) SHARECITY100 Database, Trinity College Dublin, Ireland. Retrieved from: http://sharecity.ie/research/sharecity100-database/

studies addressed to better understand consumers' behavior in relation to food waste (Diaz-Ruiz et al., 2018; Díaz-Ruiz et al., 2015a).

1.3.Conceptual framework to distinguish structural and circumstantial causes

According to the High Level Panel of Experts (HLPE) on Food Security and Nutrition (HLPE, 2014), the causes of food waste are complex and can be classified into three levels—micro, meso, and macro—according to their complexity and relationship with other drivers, as follows:

- *Micro causes:* specific causes of food waste occurring at each stage of the food supply chain due to the actions or inactions of agents at the same stage. They are not necessarily linked to other causes. Micro causes are not influenced by the behavior of agents at other stages.
- *Meso causes*: secondary or structural causes that can be found in another stage. They occur because of the interaction between agents or because of the existing infrastructures where food is produced, distributed, sold, and so forth.
- *Macro causes:* those rooted in the food system dynamics as a whole. These are systemic issues affecting the two previous levels (micro and meso), such as the policy conditions in terms of regulation or the functioning of the food system; that is, "macro causes favour the emergence of all the other causes of food loss and waste" (HLPE, 2014).

Distinguishing between these three groups of causes is useful to evaluate the magnitude and the nature of the problem posed by food waste in each case. This classification helps to differentiate between the circumstantial nature of the causes of food waste, aligned with the micro causes, and the structural nature of the causes of food waste, aligned with the meso and macro causes.

Alternative literature has suggested other classifications, as well, to disentangle the true nature of the different causes. In this study, we will use such classifications to better describe the identified causes. Thus, the causes of food waste within each level (micro, meso, and macro) can be subdivided into four additional categories: 1) *technological* causes (Canali et al., 2017; Priefer et al., 2016), which are related to technical inefficiencies or failures at different stages of the food supply chain; 2) *economic and business management* causes (Canali et al., 2017; Göbel et al., 2015; Priefer et al., 2016; Thyberg and Tonjes, 2016), linked to the business strategies of the different actors along the food chain: contract standards, operational actions, and the commercial relationships of the stakeholders in the food chain; 3) *regulatory and policy* causes (Canali et al., 2017; Göbel et al., 2015; Priefer et al., 2016), which are rooted in norms and regulations that affect the food sector, such as urban waste or food regulations, which may affect food waste generation; and 4) *appreciation and enhancement* causes (Göbel et al., 2015; Priefer et al., 2016;

Thyberg and Tonjes, 2016) (also known as values, information, and skills in other studies), which are related to awareness, information, or specific habits. Finally, the specific stages of the food supply chain where the identified causes apply are also relevant to analyze the food waste conundrum.

1.4. Material and methods

To achieve the objectives of this research, we conducted in-depth interviews of members of a panel of stakeholders from the case study region (the metropolitan region of Barcelona). Thereafter, we analyzed the results considering the conceptual framework described above. We explain the procedure of the interviews and the characteristics of the panel below.

1.4.1. In-depth interviews procedure

Semi-structured interviews were conducted of 24 key stakeholders along the food supply chain in the metropolitan region of Barcelona to elicit their perceptions on food waste and its causes along the food supply chain and at all stages. Semi-structured interviews—in which the researcher makes use of an interview guide, which is not fixed—are a useful tool for gathering in-depth insights. Researchers can modify the question flow and adapt it to the answers of the interviewee, who, on the other hand, answers all the questions without any limitation. This method is especially appropriate in exploratory studies. One of its weaknesses, however, is that it is time consuming and, hence, costly (Viedma, 2009).

The interview guide included different questions about the importance of food waste, the interviewee's interest in the prevention of food waste, an evaluation of food waste conceptual frameworks, the interviewee's knowledge about the current volume of food waste along the food supply chain, the allocation of responsibilities for the volume of generated food waste, and the causes of the generation of the volume of food waste along the food supply chain[5]. The survey was focused on the situation of the metropolitan region of Barcelona. Due to the maturity of the food waste phenomenon, we did not restrict the concept of food waste to a specific definition; instead, we discussed it in a very broad sense (food waste was understood as food that had been thrown away). It is worth noting that all the stakeholders participated in the identification of the causes at different stages of the supply chain regardless their field of activity.

The interviews were conducted from October 2014 to January 2015. They lasted from 45 to 100 minutes and were recorded and verbatim transcribed. Subsequently, the meaning of the texts were examined through qualitative content analysis (Viedma, 2009). The concepts were coded and classified according to the discussion guide, tendencies, and observed patterns. After

[5] The interview also included questions about possible solutions to food waste, which were discussed at the end of the interview. This part of the interview was beyond the scope of this paper and is therefore not included.

analyzing each interview by means of content analysis, we classified and summarized the causes following three criteria: 1) the level (micro, meso, and macro), 2) the nature (technological, economic and business management, regulatory and policy, and appreciation and enhancement), and 3) the stages of the food chain involved.

1.4.2. Sampling

The aim of the study required a sample of stakeholders that was as diverse as possible. Therefore, we chose the intentional sampling technic, commonly used in qualitative studies where experts' judgments are necessary. It is a non-probabilistic method in which the selection of the participants is based on a subjective criterion related to the aim of the study (Del-Val-Cid, 2009). We performed it using the snowball technique; individuals from initial interviews identified new participants. The value of each respondent is related to his/her particular understanding of the phenomenon studied. Therefore, it is important that, more than the number of interviews, the sample represents all the perspectives about the phenomenon. The sampling is finished when the interviewees do not offer alternative answers in explaining the phenomenon.

We obtained a final sample of 24 stakeholders from along the food supply chain and with different profiles (see Table 1.2.). A total of 4 representatives from the primary production (a regional public body, a metropolitan body, a farmers' organization, and an ecologic farmers' cooperative), 2 members from the food industry (a representative from a food industry association and a food industry group), 2 from the wholesale market (1 wholesale central market body and a small wholesaler), 4 distribution participants (3 from supermarkets of different sizes and 1 local food markets organization), 2 consumer associations, 2 redistribution entities (a food bank and a local food pantry), 1 social enterprise with a gleaning redistribution and a food transformation model, 1 expert on food waste from the university, 1 environmental NGO, 1 freegans organization, 3 regional public bodies (in food safety, waste management, and consumption), and 1 municipality environmental department were included.

Table 1.2. Sample characteristics

	Food supply chain	Farm	Processing	Wholesale	Retail	Redistribution	Consumers	Education
Social Enterprise "rescue" food	●							
Food safety regional body	●							
Waste management regional body	●							
Environmental municipality	●							
Regional consumption body	●							
Primary production metropolitan body		●						
Agri-food regional body		●						
Farmers' organization		●						
Farmers' ecologic cooperative		●						
Industry association			●					
Industry			●					
Wholesaler central market body				●				
Small wholesaler				●				
Retailer					●			
Retailer					●			
Retailer					●			
Local Markets body					●			
Charity Food pantry						●		
Charity Food Bank						●		
Local Popular dinning "freegans"							●	
Consumer association							●	
Consumer association							●	
Expert academia								●
Environmental NGO								●

1.5. Results and discussion

The in-depth interviews were analyzed through exhaustive content analysis to get insights into the regional stakeholders' perceptions on food waste, their knowledge about the volume of food waste, their views regarding who is responsible for its generation, and their food waste conceptualization. Furthermore, we collected all the potential causes of food waste that emerged during the interviews using HLPE's framework (micro, meso, and macro) (HLPE, 2014). In the following section, we show the main results and compare them with the findings of the previous literature.

1.5.1. Stakeholders perception

The stakeholders showed interest in the problem of food waste despite the fact that it was not a priority in their daily activities. Those involved directly in the food supply chain (food operators) prioritized their own business management, logistics, knowledge of consumer demand, and modernization over food waste minimization. For the rest of the stakeholders—institutions,

consumers' associations, and so forth—food waste was becoming relevant as a waste management and food security issue. All the participants demonstrated an increasing interest in the food waste phenomena during the last several years, especially due to the economic crisis and its visible impact on society. It is worth mentioning that the impact of the Spanish economic crisis, which started in 2008, was visible on society at the time of the interviews , in 2015 (e.g., an unemployment rate of 22% and, an AROPE rate[6] of 28.6 (INE, 2018).

Despite their recognition of the great importance of the problem, we observed a generalized lack of knowledge about the volume of food waste along the food supply chain. The participants were reluctant to quantify the magnitude of the problem either in volume or in percentage. On the contrary, they were more open to discussing who was responsible for the volume of food waste . The participants recognized that the responsibilities could not be assigned to a single food supply chain agent, but rather they should be distributed among all agents. In general, they attributed the responsibility for the generated food waste in every stage to the main stakeholder in that stage. This was true in all food supply stages except for at the farm level, where a shared responsibility among farmers, retailers, and industry agents was associated with farm food waste volumes. Considering the entire food value chain, farmers were seen as the least responsible for the volume of generated food waste. Moreover, public institutions were also seen as having a certain responsibility for the volume of food waste, although they are not directly involved with food handling. The key role of public bodies in the matter of food waste was also identified in the Flash Eurobarometer 425, when asking consumers about the role of different actors in preventing food waste (European Commission, 2015). The shared responsibility of the finding is important and reinforces HLPE's idea (HLPE, 2014) of distinguishing between the stage where the volume of food waste is found and the responsibilities associated with that volume.

It is important to note that we did not find a single conceptual framework of food waste within our panel of stakeholders. Many different words were used when referring to food waste and food loss, including concepts such as surplus, wastage, byproducts, and so on. Despite the diversity of concepts and perspectives, all of the stakeholders had in mind the same broad idea about what food waste was in order to express their perceptions about the causes. The general understanding of food waste was that it is food intended for human consumption that was not ultimately used for this purpose. Finding different perspectives and vocabularies is common in the food waste debates, as the previous literature has also shown (Bräutigam et al., 2014; Chaboud and Daviron, 2017; Hartikainen et al., 2018). This might be caused by multiple factors such as the novelty of the topic and the coexistence of multiple perspectives. The food waste debate emerged from

[6] People at risk of poverty or social exclusion, which is considered to be the case when they face at least three risks out of a battery of nine, such as struggling to feed themselves adequately, being late on payments on their home, or being unable to heat their homes in winter. http://www.ine.es/jaxiT3/Datos.htm?t=11201

different fields—food security, waste management, and nutrition, among others—which involve, per se, multiple conceptual approaches.

1.5.2. Causes of food waste

The interviews allowed us to identify a comprehensive set of causes of food waste in the metropolitan region of Barcelona. Despite the novelty of the food waste debate to some of the stakeholders, they demonstrated a great deal of knowledge of and fluidity in explaining the dynamics in the food system in the region that ultimately provoked the throwing away of food, no matter how they named it. They explained multiple circumstances and behaviors that have been synthetized and classified according to the conceptual framework explained in Section 2. We classified the causes into three main groups, micro causes, meso causes, and macro causes. In the following sections, each group is explained in more detail by subdividing the causes according to their nature (technological, economic andbusiness, regulatory and policy, and appreciation and enhancement) and the stage or stages of the food supply chain in which the cause was identified to apply (farm, wholesaler market, industry, retail, or consumption). We observed the great interest of the stakeholders in food redistribution and all the difficulties related to redistributing food not sold through marketing channels. Consequently, we included an additional section to explain the issue of food redistribution below.

1.5.2.1. Micro causes

The stakeholders described different incidentals occurring at different stages that can be identified as micro causes. Most of them were located downstream, at the wholesaler market, the food industry, the retailers, and the households. We found causes that can be classified as technological, economic and business and are appreciation- and enhancement-oriented (see Table 1.3.).

Technological

A set of technological-related causes were identified in different stages without any connection to the higher-level dynamics. Most of them have been extensively described in the previous literature as shown in Table 1.3. Technical inefficiencies during the processing and manipulation of food products take place at different stages of the food chain. The interviewees highlighted that at the wholesale market, the lack of a proper preservation and storage system could influence food waste generation. This is a commonly mentioned cause of food waste in the literature (Beretta et al., 2013; Bio Intelligence Service, 2010b; Buzby and Hyman, 2012; Mena et al., 2011a; Parfitt et al., 2010). A second cause of food waste was related to logistics, mainly when food products have to be transported over long distances. In such circumstances, the likelihood of unexpected situations and handling problems that lead to food waste may increase, which was also cited in

the work of Canali et al., (2017) and HLPE, (2014). In the food industry, the stakeholders identified the food packaging as a key issue, referring to either mistakes with the labeling or its poor quality. Packaging failures can result in product withdrawals that are neither able to be sold nor to be consumed. Such failures were identified in the industry during transportation and at the retail stage. These difficulties with packaging have been extensively documented in the literature (Beretta et al., 2013; Canali et al., 2017; Garrone et al., 2014; HLPE, 2014; Mena et al., 2014, 2011a; Parfitt et al., 2010; Quested et al., 2013). The improper use of food technology, mentioned also in Buzby et al., (2014) and Gustavsson et al., (2011), was relevant to our stakeholders as well. The lack of food waste prevention in the manufacturing processes was also raised as an issue, that is, not reintroducing to the manufacturing line shrinkages and surpluses that may occur during the manufacturing of food.

Economic and business management

Concerning the commercial dynamics, the stakeholders pinpointed the drivers of food waste at the food industry, retail, and household levels. The lack of sales planning, which is widely cited in previous studies (Bio Intelligence Service, 2010b; Canali et al., 2017; Gustavsson et al., 2011; HLPE, 2014; Mena et al., 2011a; Parfitt et al., 2010), was also identified to be one of the main drivers of food waste at the wholesale market and retail levels. The agents at these stages were acknowledged to have the tendency to work on a daily basis. Moreover, possible mistakes when ordering products to be sold can create food waste at the selling points. Within the industry, not using the best available techniques withoutentailing excessive costs, was mentioned as a driver of the industry's food waste.

At the retail level, the stakeholders differentiated between the dynamics of small stores and those of supermarkets and hypermarkets. In small stores, the size of the business and the provisioning system used (mainly purchases at the wholesale market) were singled out as possible drivers of food waste. For instance, some interviewees explained a common practice among small store managers, who buy products on promotion at the wholesaler—usually an offer with a very short perishability timespan—which increases the likelihood of having the food spoil later on at the store. This is not the case with supermarkets, in which the provisioning system is more systematized. However, the contact with the client is less direct and close in supermarkets than in small stores, which creates specific difficulties with relation to food waste. For instance, some stakeholders explained that supermarkets lack a good mechanism for adapting a retailer's supply to consumer demand patterns, which is a possible driver of food waste. This is crucial to avoid disappointing sales expectations and to encourage the successful acceptance of a new product release or promotion, the failure of which could result large quantities of food waste on the store at a given moment. Moreover, in supermarkets, fresh food, especially fruits and vegetables, are

visible and accessible to consumers who sometimes incorrectly manipulate them. This manipulation might result in damage to the fruits and vegetables, which must then be removed from sale.

Appreciation and enhancement

A generalized lack of knowledge and awareness regarding food waste among the different actors of the food supply chain was largely pointed out during the interviews. On the commercial side of the supply chain, the interviewees highlighted that business strategies are more focused on economic profits over environmental or social considerations. Nevertheless, the issue of food waste is gaining interest in the food sector, and this situation can potentially change in the near future through corporate social responsibility actions. The interviewees noted a widespread lack of awareness about the volume each actor generates in their own activity (from processors to households), which was also pointed out by Parizeau et al., (2015). The stakeholders offered different arguments to explain such circumstances. Some of them believed that waste management was not identified as a priority in companies' strategies, and, historically, it has been very difficult to quantify it correctly. Others believed that companies seem to be reluctant to work on waste reduction.

Consumers were also singled out for their lack of knowledge regarding food waste and the poor management of food at home, which has been extensively covered in previous studies (e.g., Bio Intelligence Service, 2010a; Buzby and Hyman, 2012; HLPE, 2014; Parfitt et al., 2010). The interviewees underlined the existence of myths and legends about food safety that influence consumers' management of food. They claimed that consumers simply throw away what they think it is not good to eat. In this context, the lack of knowledge about expiration and best before dates was the main reason for the generation of food waste in the household. Furthermore, the stakeholders mentioned some incorrect purchasing habits (e.g., purchases oriented to promotions, shopping routines and patterns, and bad purchasing planning) and cooking habits (e.g., cooking more quantity than needed, damaging food while cooking, and the lack of knowledge on how to preserve food and leftovers), together with a possible lack of interest in cooking properly, as some of the more significant causes of food waste in the home.

Table 1.3. Micro causes of food waste

		F	W	I	D	C
Technological	– Insufficient preservation systems (Beretta et al., 2013; Bio Intelligence Service, 2010b; Buzby and Hyman, 2012; Mena et al., 2011a; Parfitt et al., 2010)		●			
	– Problems with transportation and handling (Canali et al., 2017; HLPE, 2014)		●	●	●	
	– Mistakes in labeling			●		
	– Difficulties re-introducing surpluses in the manufacturing line (Buzby et al., 2014; Gustavsson et al., 2011)			●		
	– Poor quality of packaging (Beretta et al., 2013; Canali et al., 2017; Garrone et al., 2014; HLPE, 2014; Mena et al., 2014, 2011a; Parfitt et al., 2010; Quested et al., 2013)			●	●	
Economic and business	– Errors during purchasing within companies		●		●	
	– Lack of sales planning (Bio Intelligence Service, 2010b; Canali et al., 2017; Gustavsson et al., 2011; HLPE, 2014; Mena et al., 2011a; Parfitt et al., 2010)		●		●	
	– Not using the best available techniques			●		
	– Lack of adaptability to the consumer demand pattern				●	
	– Response time and capability of selling food about to expire				●	
	– Failed sales expectations				●	●
	– Negative response of clients to a new promotion				●	●
	– Clients incorrectly manipulating food at the store				●	●
Appreciation and enhancement	– Primacy of economic profits		●	●	●	
	– Difficulties of quantifying food waste		●	●	●	
	– Waste management not being a priority in the business sector		●	●	●	
	– Companies' daily dynamics making it difficult to be aware of the inefficiencies			●	●	
	– Companies' reluctance to work on waste reduction			●	●	
	– Lack of awareness of the volume of food waste (Parizeau et al., 2015)			●	●	●
	– Lack of knowledge of consumers (food, date labeling)					●
	– Poor management of food at home (Bio Intelligence Service, 2010b; Buzby and Hyman, 2012; HLPE, 2014; Parfitt et al., 2010)					●

Note: F: farm; W: wholesaler market; I: industry; R: retail (supermarkets, small stores); and C: consumption

1.5.2.2. Meso causes

We identified different causes linked to certain norms and regulations, business management, the forecast of agriculture, and lifestyle in general (see Table 1.4.).

Economic and business management

The interviewees mentioned several business practices at one stage of the supply chain that can generate food waste in other stages. Most of them were related to retailers' practices, affecting farmers and wholesalers. One that was frequently mentioned was last minute cancellations, which is also explained in the previous literature (Bio Intelligence Service, 2010a; Canali et al., 2017; Quested et al., 2013). Another bad practice was the quality and commercial requirements (not standards regulations) that retailers demand of farmers and the food industries. This has been already identified previously in other studies (Bio Intelligence Service, 2010b; Parfitt et al., 2010). These excessive requirements also influence food waste in other stages, such as the wholesale market (for example, clients not buying small fruits, because they are difficult to manipulate,

wash, peel, etc.), supermarkets, and small stores. Moreover, some stakeholders mentioned a specific situation, which does not happen very often, in which the response time of insurances companies in cases of truck accidents could also increase the likelihood of food being wasted.

At the supermarket level, the interviewees highlighted that the tendency of retailers to keep as much of a variety of products as possible until the very end of the day can be one important cause of food waste in stores. Mena et al., (2011) and HLPE (2014) have explained this in their publications.

Although farmers around the metropolitan region of Barcelona are not the main food suppliers to the region, primary production received great attention from our stakeholders. As Canali et al., (2017), it seems that an important driver of food waste at the farm sector is the lack of agricultural production planning. The stakeholders believed that farmers in the region have an individualist behavior, following the so-called "pendulum law". Farmers decide what to cultivate next season depending on the existing prices of the current one. Therefore, for different specific produce, scarce seasons with high prices and low food waste are followed by seasons characterized by excess supply, lower prices, and higher volumes of food waste.

Regional idiosyncrasies were also found to be a potential determinant of farms' food waste. There are no transformation alternatives in the metropolitan region in the case of production surpluses. Some interviewees specified that it is hard to establish a transformation infrastructure and compete with regions that are specialized in that. Moreover, they highlighted a clear lack of cooperation among producers, which is also mentioned in HLPE (2014). The individualism that characterizes farmers in the metropolitan region of Barcelona makes it difficult to come to agreements, organize farmers within a farmer's cooperative, and find alternative marketing channels when traditional markets are saturated. Furthermore, even in the case where some light cooperative behavior exists, farmers do not strictly market their products through the cooperative. Some of the stakeholders hypothesized that this can be incentivized somehow by the proximity to the big central wholesale market in Barcelona, which constitutes an advantage and a disadvantage at the same time. The advantage is that farmers can quickly respond to demand shocks at the wholesale market, attracted by higher price. However, passing over the cooperative debilitates its structure to find alternatives in a surplus/low-prices scenario.

Regulation and policy

Specific standards and regulations were discussed during the interviews. The existence of certain rules or standards among food operators on the quality or the aesthetics and sizes of produce (e.g., EU No 543/2011)—which, indeed, are widely described in previous studies (Beretta et al., 2013; Buzby and Hyman, 2012; Canali et al., 2017; Garrone et al., 2014; Göbel et al., 2015)—induce food waste at different stages of the food supply. The interviewees cited also

the potential food waste occurring due to the expiration date norms. Apart from the specific regulations, some conventions in the food industry generate large volumes of food waste according to our stakeholders. They referred to the so-called "one-third rule", which divides the product's expiration date (also applied to "best before" dates) into three parts. Each part is allocated to a stage: the industry, the supermarket, and consumers' households. Therefore, the first third of the date notes the maximum date that the product can be commercialized from the industry to other agents. The second third of the date is the time the product can be kept on a supermarket's shelves. Finally, the last third of the expiry or best before date margin is the date until which the product can be kept in consumers' households. This means that if a product is about to pass the first third of its date in the industry, it will be thrown away instead of being sold to a distributor, and the same will take place in the supermarkets. Similar behaviors have been identified in Garrone et al., (2014) and Quested et al., (2013).

Appreciation and enhancement

At the household level, the family structure was mentioned as one potential driver of food waste generation (e.g., having kids or working hours), as described in Parfitt et al., (2010) and Parizeau et al. Parizeau et al., (2015). The stakeholders also mentioned that the percentage of the family expenditure allocated to food purchasing has decreased considerably over the last few years. Therefore, food expenditure is not so relevant compared with other household expenses[7] and can be a possible cause of household food waste, which has also been raised in Canali et al., (2017) and Parfitt et al., (2010). Lifestyle was also identified during the interviews as a driver of food waste. Lifestyle is not a single behavior, but rather a combination of habits and values that influences food waste generation (Evans, 2011).

[7] In Spain, the percentage of family income allocated to buy food and beverages decreased from 48.7% in 1964 to 14% in 2017 (INE, 2018) http://www.ine.es/jaxiT3/Datos.htm?t=24900

Table 1.4. Meso causes of food waste

		F	W	I	D	C
Economic and business	– Lack of transformation alternatives in the case of farm surpluses	●				
	– No agricultural planning ("Pendulum law") (Canali et al., 2017)	●				
	– No selling forecast and strategy	●				
	– Absence of cooperation of farmers (HLPE, 2014)	●				
	– Last minute cancelations (Bio Intelligence Service, 2010a; Canali et al., 2017; Quested et al., 2013)	●	●	●	●	
	– Quality and commercial requirements (Bio Intelligence Service, 2010b; Parfitt et al., 2010)	●		●	●	●
	– Response time of insurances		●			
	– Huge variety until the end of the day (HLPE, 2014; Mena et al., 2011a)				●	
Regulatory and policy	– Quality standards and regulations (Beretta et al., 2013; Canali et al., 2017; Garrone et al., 2014; Göbel et al., 2015)	●	●	●	●	
	– Expiration date norms			●	●	●
	– "One-third rule" (Garrone et al., 2014; Quested et al., 2013)			●	●	
	– Cosmetic standards and requirements (Buzby and Hyman, 2012; Canali et al., 2017)			●	●	
App.	– Family structure (Parfitt et al., 2010; Parizeau et al., 2015)					●
	– Percentage of the income invested in food (Canali et al., 2017; Parfitt et al., 2010)					●

Note: F: farm, W: wholesaler market, I: industry, D: distribution (supermarkets, small stores), C: consumption; App.: Appreciation and enhancement

1.5.2.3. Macro causes

We found a quite range of causes identified during the interviews that are classified as macro causes. They are mostly economic- and business management-oriented drivers, although regulatory- and policy-related appreciation and enhancement and technological-related drivers were also identified. All the actors of the food supply chain were involved in these drivers. Yet, farmers and households, the two extremes, were those who were mainly implicated in the macro causes we found (see Table 1.5.).

Technological

Food system infrastructures can have an important influence on other drivers that increases the likelihood of food waste generation. The difficulties and inefficiencies of the cold supply chain infrastructure were mentioned as a difficulty of guaranteeing the preservation of food and food safety, which might result in food waste. This has been widely described in the literature (Bio Intelligence Service, 2010b; Canali et al., 2017; HLPE, 2014; Mena et al., 2011a; Parfitt et al., 2010).

Economic and business management

A recurring issue that emerged during the interviews was the supply–demand mismatch of fresh food as a major determinant of food waste at different levels of the food supply chain. The stakeholders noted the national overproduction of food, which was also identified in previous studies (Beretta et al., 2013; Garrone et al., 2014; Gustavsson et al., 2011). The interviewees pointed out the tendency to oversupply food in a highly competitive market. This results in the

payment of lower prices to producers that often do not even cover the costs of production. Thus, agricultural products are not harvested, a problem also shown previously (Buzby et al., 2014; Canali et al., 2017; Gustavsson et al., 2011).

Moreover, some of the stakeholders pointed out that production and marketing models could also have a significant influence on the volume and the type of food waste that is generated. At the production stage, they suggested differentiating between two production models, the industrial agricultural model and the organic production model. The former was seen as a generator of significant waste volume, whereas the latter faces other problems, such as pest control or the marketing of the produce. As regards the marketing model, the structure and composition of the food supply chain could benefit or complicate the distribution of products that are about to expire. At the consumer stage, some stakeholders highlighted the purchasing options of consumers as a possible driver of food waste. They specified that, although consumers have lost purchasing options in some distribution models, the availability of stores has increased, so it is easier to buy food products at any time.

We already identified the lack of agricultural planning as a meso cause of food waste. However, the interviewees mentioned the difficulties of farmers of forecasting their production due to factors beyond their control, not only in the metropolitan region. Fresh perishable food production is highly variable and depends on uncontrollable climate conditions—good climatic conditions could lead to excess supply and food waste. Furthermore, it was pointed out that farmers operate in a global market where geopolitics (e.g., Russian veto) and food safety crises (e.g., cucumber scandal) could also have a huge impact on food waste.

Regulatory and policy

Some stakeholders indicated the influence that policy decisions could have on food waste generation. This is also supported by the European Court of Auditors in their special report on *"Combating Food Waste: an opportunity for the EU to improve the resource-efficiency of the food supply chain"* (European Union, 2016). In particular, some interviewees expressed their concern regarding certain regulations that promote the perfection of the external appearance and freshness of food. Consistent with the previous literature (Buzby and Hyman, 2012; Canali et al., 2017; Garrone et al., 2014), the members of our panel specified that excessive quality, size, and aesthetic standards induce food waste along the food supply chain. However, there was not a clear consensus about who is responsible for fixing such standards. Some referred to the ultimate and implicit consumer quality requirements; others held retailers responsible, and others considered that there is a shared responsibility influenced by the dynamics of the food system. Food safety standards and food labeling rules were also mentioned during the interviews. The stakeholders pointed out that a possible excessive implementation of these rules could lead to food waste

generation. They also cited certain regulations not being clear and leaving space for misinterpretations. Some examples provided were the expiration or selling dates included in labels or the misinterpretations of animal byproduct flexibility on the interpretation of its categories (e.g., Regulation (EC) No 1069/2009).

Appreciation and enhancement

The interviewees recurrently mentioned the importance of the knowledge and awareness of different agents about food waste and its impact. They perceived a certain lack of knowledge about food waste as a potential resource to use, not only at the household level, but also along the whole supply chain. Specifically, they highlighted the limited awareness of stakeholders about the economic impact of food waste at the farm, wholesale, food industry, and retail levels. In relation to consumers, some stakeholders pointed out the level of importance citizens attached to food and diet as a possible driver of food waste. Parfitt et al., (2010) and Stuart, (2009) have also described the role of food in citizen life and how this can have a relevant influence on multiple behaviors, including food waste. In relation to valuing food, some stakeholders went one step further and linked the lack of social awareness and the involvement of every citizen with societal problems as a potential predictor of food waste.

Table 1.5 Macro causes of food waste

		F	W	I	D	C
T	– Difficulties of guaranteeing the cold chain (Bio Intelligence Service, 2010b; Canali et al., 2017; HLPE, 2014; Mena et al., 2011a; Parfitt et al., 2010)	●	●	●	●	
Economic and business	– National overproduction (Beretta et al., 2013; Garrone et al., 2014; Gustavsson et al., 2011)	●				
	– Low prices that do not cover the costs (Buzby et al., 2014; Canali et al., 2017; Gustavsson et al., 2011)	●				
	– Difficulties planning agriculture (variability, global market, cancelations)	●				
	– Market competitiveness	●	●	●	●	●
	– Production model of big volumes	●	●	●	●	
	– Food–supply–chain infrastructure	●	●	●	●	●
	– Difficulties introducing a product about to expire into the market	●	●	●	●	●
	– Consumer loss of buying options				●	●
	– Consumers' ability to buy food products at any time				●	●
	– Generalized oversupply in the distribution.				●	
Reg.	– Legislation promotes perfectness and freshness	●				
	– Excessive application of food safety standards and food labeling	●	●	●	●	
	– Misinterpretations of regulations	●	●	●	●	●
	– Quality, size, and aesthetic standards (Buzby and Hyman, 2012; Canali et al., 2017; Garrone et al., 2014)	●	●	●	●	●
App.	– Lack of knowledge that food waste is a resource	●	●	●	●	●
	– No awareness of the economic impact of food waste	●	●	●	●	
	– No concern for the food value and the importance of diet and food (Parfitt et al., 2010; Stuart, 2009)					●
	– Lack of social awareness and implication of citizens					●

Note: F: farm; W: wholesaler market; I: industry; R: retail (supermarkets, small stores); C: consumption; T.: technological; Reg.: regulatory and policy; and app.: Appreciation and enhancement

1.5.2.4. Redistribution

The stakeholders showed a great interest in pointing out all sorts of difficulties that farmers, wholesalers, and supermarkets, as well as social entities, face when increasing redistribution in the metropolitan region. Although the issue of food redistribution, as an acceptable alternative to food waste prevention and reduction, has been treated extensively in the literature (Cristóbal et al., 2017; Cristóbal Garcia et al., 2016; González-Torre et al., 2016; Priefer et al., 2016; Thyberg and Tonjes, 2016), no previous study has referred to such difficulties (see Table 1.6.).

At the farm and wholesaler levels, the main obstacles raised during the interviews were related to logistics (the cold storage infrastructure for perishable products and the time constraints to redistribute surpluses). Social entities, which, in turn, would be the main beneficiaries of redistribution, also have some logistical problems related to their storage capacity (the lack of space in food pantries and cooling systems). Collecting and transporting such big quantities of fresh produce from farms was also mentioned, as well as the quality of the fresh produce donated by farmers and wholesalers. Sometimes, donations of surplus produce need some manipulation and processing to sort food that is adequate for human consumption from that which is not. This triage requires time and available space, which is scarce in food pantries. In Catalonia, there is a funded program of the Barcelona Food Bank to transform fruits into juices. However, it is difficult for industries, at specific moments in time, to absorb such big quantities of produce and transform it before it is spoiled. Some participants also highlighted the difficulties of engaging farmers in food donation.

The interviewees identified some difficulties of redistributing food from retailers (either big supermarkets or small stores) to social entities. First, there seems to exist some logistical problems, as retailers would not have enough space to allocate to food that cannot be sold but should be donated. They also highlighted the difficulties caused by fresh produce and food sold loose (non-pre-packaged food), for instance, guaranteeing cold meat traceability and the best before dates of batches. Workers of supermarkets were identified as key actors in the process of donation. Therefore, food safety precautions, poor information, and the protocols of supermarket workers could hinder food donations.

Finally, some of the participants highlighted some difficulties that social entities (food pantries and food banks) face with respect to receiving and redistributing food. The structure and composition of social entities, heavily depending on volunteers, limit the collection of food from supermarkets. Moreover, the collected food requires very fast redistribution to beneficiaries, which is not always possible due to the food pantries' service hours. The bureaucracy and regulations regarding food donation were also highlighted as causes of food waste. Bureaucratic difficulties make it easier for supermarkets to throw food away, rather than storing it, preparing

the documentation, and donate it. Moreover, some stakeholders pointed out that there are false myths regarding food donation that create some perceived legal barriers that hinder donations from retail companies.

Table 1.6. Food redistribution difficulties

		F	W	I	D	C	R
Te.	– Farmers' difficulties regarding logistical capacities	●					
	– Charities or social dinners' difficulties in preserving fresh produce						●
	– Lack of space for keeping the food or the redistribution of it				●		●
Econ.	– Urgency to distribute in the case of farm surpluses	●					●
	– Manipulation of the donated food is needed						●
	– Difficulties and reluctance of retailers to donate food				●		
	– Volunteers' reliance on food charities				●		●
	– Difficulties of food recovery transportation				●		●
Re	– Potential donors misunderstanding the regulations and bureaucracy				●		
A	– Lack of interest in or knowledge of donations protocols		●	●	●		

Note: F: farm; W: wholesaler market; I: industry; R: retail (supermarkets, small stores); C: consumption; RR: redistribution; Te.: technological; Econ.: economic and business; Re.: regulatory and policy; and A.: appreciation and enhancement

1.6. Conclusions

To achieve more sustainable food systems, it is crucial to better understand all the negative externalities affecting such systems. This study has tried to conduct a comprehensive analysis of the food waste challenge, which is one of the key components of the current unsustainability of the food system. Despite the interest in preventing and reducing the current volumes of food waste, we believe that the partial approaches employed to study the situation have blurred the global comprehension of the nature of the problem. This paper has aimed to contribute to fill this gap by undertaking a participatory, holistic, and whole supply chain analysis of the causes of food waste generation in the metropolitan region of Barcelona. In line with the HLPE (2014), we proposed to distinguish between the micro, meso, and macro nature of the causes of food waste generation. We employed this distinction to disentangle the circumstantial or structural nature of food waste generation. We believe that the ways to approach and solve these two groups of causes should be radically different. Incidental or circumstantial causes can be addressed with stage-focused approaches. However, structural causes require holistic approaches.

We fulfilled the two main objectives of the paper. First, the relevant stakeholders' perceptions and the causes of food waste in the metropolitan region were identified and detailed. The stakeholders in this study have shown a great interest in food waste prevention. The social dimension of the problem (the difficulties of access to food faced by some segments of the population) is a key factor for the stakeholders. Therefore, food redistribution raised a key issue during interviews. Moreover, the farming level was focused upon substantially, despite the fact that the metropolitan region is not a high-food-producing region. We provided a detailed

description of the dynamics that cause food waste at different stages in the region. From our findings, policymakers in the region can better decide which causes they should prioritize and where they should focus their attention to design possible interventions to prevent and reduce the volume of food waste . Further research on the feasibility and efficacy of addressing the causes identified in this paper are needed to draw further considerations. In this paper, we aimed at developing a comprehensive scenario to introduce into the policy debates.

Secondly, this paper has differentiated between the circumstantial and structural causes of food waste. The approach used in this study has allowed us to identify the complexity of the food waste conundrum. Food waste drivers are spread throughout different stages of the food supply chain, at different levels—micro, meso, and macro. Potential solutions should be approached in a different way. Micro causes were identified in relation to the existing inefficiencies of specific processes at specific stages of the food supply chain. Hence, partial and focused measures and approaches would be enough to solve them.

On the other hand, the meso and macro causes mentioned by the stakeholders are mainly related to the food system dynamics and the existing interrelationships among the stakeholders in the food supply chain. They cannot be understood with partial views, and whole-supply-chain measures are needed. The results from this study indicate that food waste is a structural problem, which is mainly linked to the current structure of the food supply chain and not to particular and isolated inefficiencies. Overall, our results are in line with the partial results found in the literature. However, this study provides a more global perspective. This holistic approach should be followed in future research in order to corroborate our results in other geographical contexts.

Food waste is a complex issue affecting a large number of agents. Although food waste awareness has significantly increased during the last decade, the literature review made in this study indicates a lack of studies on food waste causes that utilize whole-supply-chain approaches. It is true that in the area of consumer behavior, there is increasing research focused on understanding consumers' behavior and perceptions. However, consumers do not hold the ultimate responsibility for food waste. Our research contributes to the literature by providing a regional stakeholders' perspective about food waste along the food supply chain.

Finally, this study shows that the regional scope is an adequate scale in which to analyze the problem of food waste. We found specifications from the region that would not have been identified with a broader geographical scope (e.g., national, European, worldwide). Most of the studies on food waste published in peer-reviewed journals are located in the United States or the United Kingdom. Replicating more regional studies would contribute to the international debate, and we would be able to identify alternative policies more adapted to the relevant territories and cultures.

References

Abiad, M.G., Meho, L.I., 2018. Food loss and food waste research in the Arab world: a systematic review. Food Secur. 10, 311–322. doi:10.1007/s12571-018-0782-7

AECOC, 2016. La alimentación no tiene desperdicio, aprovechala [WWW Document]. URL http://www.alimentacionsindesperdicio.com/ (accessed 10.10.16).

ARC, 2016. Som gent de profit [WWW Document]. Catalan Waste Agency. URL http://somgentdeprofit.cat/); (accessed 10.10.16).

ARC, 2014a. Els residus generats per les indústries inscrites en el registre de productors de residus de Catalunya. Dades 2013. Barcelona.

ARC, 2014b. Dades estadístiques de residus municipals de l'any 2013. Barcelona.

ARC, UAB, 2011. Diagnosi del malbaratament alimentari a catalunya. Resum executiu.

Àrea Metropolitana de Barcelona;, Institut Cerdà, 2017. La dimensió econòmica del sistema alimentari a l'àrea metropolitana de Barcelona: Abast, reptes i oportunitats.

Bellemare, M.F., Çakir, M., Peterson, H.H., Novak, L., Rudi, J., 2017. On the Measurement of Food Waste. Am. J. Agric. Econ. 99, 1148–1158. doi:10.1093/ajae/aax034

Beretta, C., Stoessel, F., Baier, U., Hellweg, S., 2013. Quantifying food losses and the potential for reduction in Switzerland. Waste Manag. 33, 764–773. doi:10.1016/j.wasman.2012.11.007

Beretta, C., Stucki, M., Hellweg, S., 2017. Environmental Impacts and Hotspots of Food Losses: Value Chain Analysis of Swiss Food Consumption. Environ. Sci. Technol. 51, 11165–11173. doi:10.1021/acs.est.6b06179

Bio Intelligence Service, 2010a. Preparatory study on food waste Across EU 27. Technical Report 2010-254.

Bio Intelligence Service, 2010b. Preparatory Study on Food Waste Across EU 27. doi:10.2779/85947

Blay-Palmer, A., Santini, G., Dubbeling, M., Renting, H., Taguchi, M., Giordano, T., 2018. Validating the City Region Food System Approach: Enacting Inclusive, Transformational City Region Food Systems. Sustainability 10, 1680. doi:10.3390/su10051680

Bräutigam, K.-R.R., Jörissen, J., Priefer, C., 2014. The extent of food waste generation across EU-27: Different calculation methods and the reliability of their results. Waste Manag. Res. 32, 683–694. doi:10.1177/0734242X14545374

Buzby, J.C., Hyman, J., 2012. Total and per capita value of food loss in the United States. Food Policy 37, 561–570. doi:10.1016/j.foodpol.2012.06.002

Buzby, J.C., Wells, H.F., Hyman, J., 2014. The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States. Econ. Inf. Bull. 39.

Campbell, H., Evans, D., Murcott, A., 2017. Measurability, austerity and edibility: Introducing waste into food regime theory. J. Rural Stud. 51, 168–177. doi:10.1016/j.jrurstud.2017.01.017

Canali, M., Amani, P., Aramyan, L., Gheoldus, M., Moates, G., Östergren, K., Silvennoinen, K., Waldron, K., Vittuari, M., 2017. Food waste drivers in Europe, from identification to possible interventions. Sustain. 9, 37. doi:10.3390/su9010037

Chaboud, G., 2017. Assessing food losses and waste with a methodological framework: Insights from a case study. Resour. Conserv. Recycl. 125, 188–197. doi:10.1016/j.resconrec.2017.06.008

Chaboud, G., Daviron, B., 2017. Food losses and waste: Navigating the inconsistencies. Glob. Food Sec. 12, 1–7. doi:10.1016/j.gfs.2016.11.004

Cristóbal, J., Castellani, V., Manfredi, S., Sala, S., 2017. Prioritizing and optimizing sustainable measures for food waste prevention and management. Waste Manag. 72, 3–16. doi:10.1016/j.wasman.2017.11.007

Cristóbal Garcia, J., Vila, M., Giavini, M., Torres De Matos, C., Manfredi, S., 2016. Prevention of Waste in the Circular Economy: Analysis of Strategies and Identification of Sustainable Targets - The food waste example, EUR 28422. Publications Office of the European Union, Luxembourg (Luxembourg). doi:10.2760/256208

De Menna, F., Dietershagen, J., Loubiere, M., Vittuari, M., 2018. Life cycle costing of food waste: A review of methodological approaches. Waste Manag. 73, 1–13. doi:10.1016/j.wasman.2017.12.032

Del-Val-Cid, C., 2009. Capítulo 5. La encuesta, in: Callejo Gallego, J., del Val Cid, C., Gutiérrez Brito, J., Viedma Rojas, A. (Eds.), Introducción a Las Técnicas de Investigación Social. Editorial Universitaria Ramón Areces, Madrid, p. 336.

Derqui, B., Fayos, T., Fernandez, V., 2016. Towards a More Sustainable Food Supply Chain: Opening up Invisible Waste in Food Service. Sustainability 8, 693. doi:10.3390/su8070693

Diaz-Ruiz, R., Costa-Font, M., Gil, J.M., 2018. Moving ahead from food-related behaviours: an alternative approach to understand household food waste generation. J. Clean. Prod. 172C, 1140–1151. doi:10.1016/J.JCLEPRO.2017.10.148

Díaz-Ruiz, R., Costa-Font, M., Gil, J.M., 2015. A social perspective on food waste: to what extent consumers are aware of their own food waste, in: Escajedo San-Epifanio, L., De Renobales Scheifler, M. (Eds.), Envisioning a Future without Food Waste and Food Poverty. Wageningen Academic Publishers, pp. 157–164. doi:doi:10.3920/978-90-8686-820-9_18

European Commission, 2018. A monitoring framework for the circular economy, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committe of the Regions.

European Commission, 2015. Flash Eurobarometer 425 September 2015 " Food waste and date marking." doi:10.2875/256740

European Union, 2016. Combating Food Waste: an opportunity for the EU to improve the resource-efficiency of the food supply chain. Special report NO 34 (EN). European Court of Auditors (ECA) - European Union. doi:10.2865/8374

European Union, 2013. Dictamen del Comité Económico y Social Europeo sobre «La contribución de la sociedad civil a una estrategia de prevención y reducción de las pérdidas y del desperdicio de alimentos» (2013/c 161/08). Diario Oficila de la Unión Europea 161/46.

Evans, D., 2011. Blaming the consumer – once again: the social and material contexts of everyday food waste practices in some English households. Crit. Public Health 21, 429–440. doi:10.1080/09581596.2011.608797

FAO, 2013. Food wastage footprint. Impacts on natural resources. Summary Report.

FUSIONS, 2016. Food waste quantification manual to monitor food waste amounts and progression.

Gamboa, G., Kovacic, Z., Di Masso, M., Mingorría, S., Gomiero, T., Rivera-Ferré, M., Giampietro, M., 2016. The complexity of food systems: Defining relevant attributes and indicators for the evaluation of food supply chains in Spain. Sustain. 8. doi:10.3390/su8060515

Garrone, P., Melacini, M., Perego, A., 2014. Opening the black box of food waste reduction. Food Policy 46, 129–139. doi:10.1016/j.foodpol.2014.03.014

Geffen, L. van, Sijtsema, S.J., Újhelyi, K., Eisenhauer, P., Diedrich, A.-C., Brumbauer, T., Díaz-Ruiz, R., López-i-Gelats, F., Reinoso Botsho, D., Winter, M. van H., Herpen, E. van, 2016. National , Qualitative insight on Household & Catering Food Waste. Wageningen, Netherlands Wageningen Univ. Econ. Res. 193.

GIZ, FAO, RUAF, 2016. City Region Food Systems and Food Waste Management.

Göbel, C., Langen, N., Blumenthal, A., Teitscheid, P., Ritter, G., 2015. Cutting Food Waste through Cooperation along the Food Supply Chain. Sustainability 7, 1429–1445. doi:10.3390/su7021429

González-Torre, P.L., Coque, J., Gonzalez-Torre, P.L., Coque, J., 2016. From food waste to donations: The case of marketplaces in Northern Spain. Sustain. 8. doi:10.3390/su8060575

Gustavsson, J., Cedeberg, C., Sonesson, U., Otterdijk, R. van, Meybeck, A., 2011. Global food losses and food waste - Extent, causes and prevention. Rome.

Hartikainen, H., Mogensen, L., Svanes, E., Franke, U., 2018. Food waste quantification in primary production – The Nordic countries as a case study. Waste Manag. 71, 502–511. doi:10.1016/j.wasman.2017.10.026

Hebrok, M., Boks, C., 2017. Household food waste: Drivers and potential intervention points for design – An extensive review. J. Clean. Prod. 151, 380–392. doi:10.1016/j.jclepro.2017.03.069

Heller, M.C., Keoleian, G.A., 2014. Greenhouse Gas Emission Estimates of U.S. Dietary Choices and Food Loss. J. Ind. Ecol. 0, 1–11. doi:10.1111/jiec.12174

HISPACOOP, 2012. Estudio sobre el desperdicio de alimentos en los hogares Estudio sobre el desperdicio de alimentos en los hogares.

HLPE, 2014. Food losses and waste in the context of sustainable food systems. A Rep. by High Lev. Panel Expert. Food Secur. Nutr. Comm. World Food Secur. Rome 2014.

Idescat, 2017. Institut d'Estadística de Catalunya [WWW Document]. URL www.idescat.cat

INE, 2018. Spanish National Statistical Institute [WWW Document]. URL http://www.ine.es/ (accessed 7.10.18).

IPES-Food, 2016. From uniformity to diversity: A paradigm shift from industrial agriculture to diversified agroecological systems, International Panel of Experts on Sustainable Food systems. doi:IPES-Food.

Katajajuuri, J.-M., Silvennoinen, K., Hartikainen, H., Heikkilä, L., Reinikainen, A., 2014. Food waste in the Finnish food chain. J. Clean. Prod. 73, 322–329. doi:10.1016/j.jclepro.2013.12.057

Magrama, 2016. Desperdicio de alimentos de los hogares en España Otoño-Invierno + Primavera-Verano 2015.

Magrama, 2014a. Las pérdidas y el desperdicio generado por la producción agrícola de alimentos en España Resumen ejecutivo.

Magrama, 2014b. Las pérdidas y el desperdicio alimentario en la distribución alimentaria , la restauración colectiva y organizada Resumen ejecutivo.

Magrama, 2014c. Las pérdidas y el desperdicio alimentario en la industria agroalimentaria española : situación actual y retos de futuro Resumen ejecutivo.

Magrama, 2013. Estrategia "más alimento, menos desperdicio" . [WWW Document]. URL http://www.magrama.gob.es/es/alimentacion/temas/estrategia-mas-alimento-menos-desperdicio/Libro_estrategia_desperdicio_baja_tcm7-271306.pdf (accessed 10.10.16).

Mena, C., Adenso-Diaz, B., Yurt, O., 2011. The causes of food waste in the supplier–retailer interface: Evidences from the UK and Spain. Resour. Conserv. Recycl. 55, 648–658. doi:10.1016/j.resconrec.2010.09.006

Mena, C., Terry, L. a., Williams, A., Ellram, L., 2014. Causes of waste across multi-tier supply networks: Cases in the UK food sector. Int. J. Prod. Econ. 152, 144–158. doi:10.1016/j.ijpe.2014.03.012

Mondéjar-Jiménez, J.A., Ferrari, G., Secondi, L., Principato, L., 2015. From the table to waste: An exploratory study on behaviour towards food waste of Spanish and Italian youths. J. Clean. Prod. 138, 8–18. doi:10.1016/j.jclepro.2016.06.018

Montagut, X., Gascón, J., 2014. Alimentos desperdiciados. Barcelona; Quito.

Mourad, M., 2016. Recycling, recovering and preventing "food waste": competing solutions for food systems sustainability in the United States and France. J. Clean. Prod. 126, 461–477. doi:10.1016/j.jclepro.2016.03.084

MUFPP, 2017. Milan Urban Food Policy Pact 3rd Annual Gathering and Mayor Summit Valencia, Spain.

Muriana, C., 2017. A focus on the state of the art of food waste/losses issue and suggestions for future researches. Waste Manag. 68, 557–570. doi:10.1016/j.wasman.2017.06.047

OCU, 2016. No tires la comida [WWW Document]. URL http://www.ocu.org/movilizate/no-tires-la-comida (accessed 10.10.16).

Papargyropoulou, E., Lozano, R., Steinberger, J., Wright, N., Ujang, Z. Bin, K. Steinberger, J., Wright, N., Ujang, Z. Bin, Steinberger, J., Wright, N., Ujang, Z. Bin, 2014. The food waste hierarchy as a framework for the management of food surplus and food waste. J. Clean. Prod. 76, 106–115. doi:10.1016/j.jclepro.2014.04.020

Papargyropoulou, E., Wright, N., Lozano, R., Steinberger, J., Padfield, R., Ujang, Z., 2016. Conceptual framework for the study of food waste generation and prevention in the hospitality sector. Waste Manag. 49, 326–336. doi:10.1016/j.wasman.2016.01.017

Parfitt, J., Barthel, M., Macnaughton, S., 2010. Food waste within food supply chains: quantification and potential for change to 2050. Philos. Trans. R. Soc. Lond. B. Biol. Sci. 365, 3065–81. doi:10.1098/rstb.2010.0126

Parizeau, K., Massow, M. von, Martin, R., 2015. Household-level dynamics of food waste production and related beliefs, attitudes, and behaviours in Guelph, Ontario. Waste Manag. 35, 207–217. doi:10.1016/j.wasman.2014.09.019

Paül, V., McKenzie, F.H., 2013. Peri-urban farmland conservation and development of alternative food networks: Insights from a case-study area in metropolitan Barcelona (Catalonia, Spain). Land use policy 30, 94–105. doi:10.1016/j.landusepol.2012.02.009

Porpino, G., Wansink, B., Parente, J.G., 2016. Wasted Positive Intentions: The Role of Affection and Abundance on Household Food Waste. J. Food Prod. Mark. 4446, Forthcoming. doi:10.1080/10454446.2015.1121433

Priefer, C., Jörissen, J., Bräutigam, K.-R., 2016. Food waste prevention in Europe - A cause-driven approach to identify the most relevant leverage points for action. Resour. Conserv. Recycl. 109, 155–165. doi:10.1016/j.resconrec.2016.03.004

Prosalus, 2016. Yo no desperdicio [WWW Document]. URL http://yonodesperdicio.org/ (accessed 10.10.16).

Quested, T.E., Marsh, E., Stunell, D., Parry, A.D., 2013. Spaghetti soup: The complex world of food waste behaviours. Resour. Conserv. Recycl. 79, 43–51. doi:10.1016/j.resconrec.2013.04.011

Raak, N., Symmank, C., Zahn, S., Aschemann-Witzel, J., Rohm, H., 2017. Processing- and product-related causes for food waste and implications for the food supply chain. Waste Manag. 61, 461–472. doi:10.1016/j.wasman.2016.12.027

Redlingshöfer, B., Coudurier, B., Georget, M., 2017. Quantifying food loss during primary production and processing in France. J. Clean. Prod. 164, 703–714. doi:10.1016/j.jclepro.2017.06.173

Roodhuyzen, D.M.A., Luning, P.A., Fogliano, V., Steenbekkers, L.P.A., 2017. Putting together the puzzle of consumer food waste: Towards an integral perspective. Trends Food Sci. Technol. 68, 37–50. doi:10.1016/j.tifs.2017.07.009

Schanes, K., Dobernig, K., Gözet, B., 2018. Food waste matters - A systematic review of household food waste practices and their policy implications. J. Clean. Prod. 182, 978–991. doi:10.1016/J.JCLEPRO.2018.02.030

Stefan, V., van Herpen, E., Tudoran, A.A., Lähteenmäki, L., L??hteenm??ki, L., 2013. Avoiding food waste by Romanian consumers: The importance of planning and shopping routines. Food Qual. Prefer. 28, 375–381. doi:10.1016/j.foodqual.2012.11.001

Stenmarck, Å., Jensen, C., Quested, T., Moates, G., 2016. Estimates of European food waste levels.

Stuart, T., 2009. Waste: Uncovering the Global Food Scandal. Penguin books, London.

Thyberg, K.L., Tonjes, D.J., 2016. Drivers of food waste and their implications for sustainable policy development. Resour. Conserv. Recycl. 106, 110–123. doi:10.1016/j.resconrec.2015.11.016

United Nations, 2015. Transforming our world: the 2030 Agenda for Sustainable Development, General Assembley 70 session. doi:10.1007/s13398-014-0173-7.2

Viedma, A., 2009. Capítulo 3. Entrevistas, in: Callejo Gallego, J., del Val Cid, C., Gutiérrez Brito, J., Viedma Rojas, A. (Eds.), Introducción a Las Técnicas de Investigación Social. Editorial Universitaria Ramón Areces, Madrid, p. 336.

Vivero-Pol, L.J., 2017. Food as Commons or Commodity? Exploring the Links between Normative Valuations and Agency in Food Transition. Sustainability. doi:10.3390/su9030442

West, P.C., Gerber, J.S., Engstrom, P.M., Mueller, N.D., Brauman, K. a, Carlson, K.M., Cassidy, E.S., Johnston, M., Macdonald, G.K., Ray, D.K., Siebert, S., 2014. Food Security and the Environment. Science (80-.). 345, 325–328.

World Resources Institute, 2016. Food Loss and Waste Accounting and Reporting Standard 160.

WRAP, 2007. Food Behaviour Consumer Research : Quantitative Phase.

WRAP, Quested, T., 2009. Household Food and Drink Waste in the UK A report containing quantification of the amount and types of household.

Xue, L., Liu, G., Parfitt, J., Liu, X., Van Herpen, E., Stenmarck, Å., O'Connor, C., Östergren, K., Cheng, S., 2017. Missing Food, Missing Data? A Critical Review of Global Food Losses and Food Waste Data. Environ. Sci. Technol. 51, 6618–6633. doi:10.1021/acs.est.7b00401

CHAPTER 2

Food waste prevention and reduction: stakeholders' engagement to define and prioritize regional solutions.

A preliminary version of this paper was presented in an European Congress in December 2015:

Diaz-Ruiz, R., Costa-Font, M., López-i-Gelats, F., Gil, J.M. ***Defining scenarios to food waste reduction: seeking for consensus among food supply stakeholders*** *Presented in 148th seminar of the EAAE, ''Does Europe need a Food Policy?", 30 November – 1 December, 2015, The Hague, The Netherlands,*

2.1. Introduction

The development of more sustainable alternatives to reverse the present food system scenario is one of the most important challenges society currently faces. There are numerous evidences highlighting the vast and increasing unsustainability of the agro-food system (Gamboa et al., 2016; IPES-Food, 2016; Vivero-Pol, 2017; P. C. West et al., 2014). The agro-food system dominant in the industrialized world is one of the most impactful human activities in generating greenhouse gas emissions, water consumption and soil utilization and depletion, among other notable effects (FAO, 2013b; P. C. West et al., 2014). Moreover, despite having more nutrients available per capita than ever, the current agro-food system is responsible for both a significant percentage of people suffering from hunger (FAO et al., 2015) and an increasing percentage of people suffering from obesity and related illnesses (FAO-FAD-UNICEF-WFP and WHO, 2017). It is in this context that we must consider that one third of food produced is lost or wasted annually (Gustavsson et al., 2011). Food waste is emerging as a key unsustainable outcome of the agro-food system that needs to be addressed.

In the policy arena, food waste prevention and reduction are being addressed at all levels: international, national, regional and local. From the international perspective, FAO has devoted resources and attention to the field. The World Resource Institute is promoting a methodological protocol to help with its measurement (World Resources Institute, 2016). The United Nations outlines a specific target (12.3) within the Sustainable Development Goals to halve food waste volumes by 2030 (United Nations, 2015). In the same vein, the European Circular Economy package highlights the importance of food waste reduction and supports the United Nations aim (European Commission, 2018). There are also country-specific initiatives promoting new laws and regulations to prevent and reduce food waste (e.g. France and Italy (Muriana, 2017)). At the regional and local levels, food waste prevention is gaining relevance in food systems sustainability debates (e.g. City Region Food Systems or the Milan Urban Food Policy Pact (MUFPP, 2017)).

The increased policy interest has been accompanied by a burst of research into food loss and waste in the last decade. Food waste studies have focused on quantifying the volume of food waste (e.g. Beretta et al., 2013; Buzby and Hyman, 2012; Chaboud, 2017; Ju et al., 2017; Willersinn et al., 2015), estimating the associated impact (e.g. Beretta et al., 2013; Brancoli et al., 2017; Campoy-Muñoz et al., 2017; Mattsson et al., 2018), finding out the root of the problem (e.g. Canali et al., 2017a; Göbel et al., 2015; Parizeau et al., 2015; Thyberg and Tonjes, 2016) and, to a lesser extent, some research has been devoted to finding solutions to prevent and reduce the current volume (e.g. Mourad, 2016; Priefer et al., 2016; Strotmann et al., 2017; Thyberg and Tonjes, 2016).

Food waste prevention and reduction measures are very diverse in terms of both scale (national, regional and local) and domain (NGOs, private companies, international platforms, public institutions), from consumer awareness campaigns to new social enterprise models. However, little is known about the impact of actions on food waste volume reduction. To provide some guidance, a number of organisations have been working on transposing the waste hierarchy from the EU Directive 2008/98/CE into a food waste hierarchy (e.g. GIZ et al., 2016; Papargyropoulou et al., 2014). The hierarchy gives priority to prevention over recycling and final disposal. Prevention encompasses numerous actions aimed at avoiding the generation of food waste. If prevention is not possible, a set of alternatives are outlined to manage these "surpluses/waste-to-be/side-flows" and avoid them being disposed and losing all their value (nutritional, energetic and so forth.). Therefore, the second preferred option is to redistribute food for human consumption. If it is not possible to recirculate this "waste-to-be" for human consumption, the following options are, in decreasing order: recycling into animal feed or composting, recovery of the embodied energy via anaerobic digestion or alternative treatments and, finally, disposal into landfills.

After a decade of public initiatives on food waste, there is no evidence showing to what extent they have contributed to reducing the magnitude of the problem (European Union, 2016). The complexity of the food waste phenomenon therefore requires further debate. New approaches are needed to analyse the appropriateness of all possible solutions. Cristóbal Garcia et al. (2016) suggested prioritizing measures with higher feasibility and a higher impact on the reduction of food waste. Although publications on this are still scarce, we found recent publications exposing and discussing different possibilities for preventing and reducing food waste and have suggested some ways to systematize and analyse multiple alternatives (Canali et al., 2017; Cristóbal et al., 2017; Cristóbal Garcia et al., 2016; Göbel et al., 2015; Mourad, 2016; Priefer et al., 2016; Thyberg and Tonjes, 2016).

The emerging publications on classifying food waste prevention and reduction actions have proposed various different approaches. Thyberg and Tonjes (2016) produced a three-level classification of solutions based on whether they are related to values, skills or logistics. Cristóbal et al. (2017), following the food waste hierarchy, distinguished among the prevention actions (e.g. consumer campaigns, standardized food labelling): reuse (e.g. tax donation incentives, transportation) and recycling-recovery (e.g. compost, animal feed). Mourad (2016) also prioritized prevention over recovery (e.g. food donation) and recycling (e.g. animal feed, anaerobic digestion). However, she highlighted the relevance of differentiating between strong and weak prevention actions, drawing a parallel with the concepts of strong and weak sustainability (Neumayer, 2003). The main difference between the two is that the former seeks holistic changes in the food system to persist over time, while weak prevention only calls for

process or behaviour improvement, thus neglecting the long-term risks and rebound effects. Figure 2.1. summarizes a possible classification and prioritization of food waste measures.

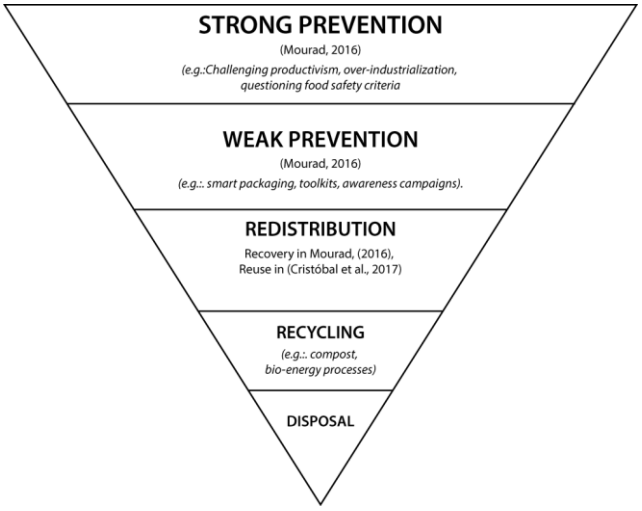


Figure 2.1 Food waste solutions priorities

More recently, some studies have pointed out the need to acknowledge the complexity of the food waste problem (Abiad and Meho, 2018; Campbell et al., 2017; GIZ et al., 2016; HLPE, 2014; Montagut and Gascón, 2014; Muriana, 2017; Papargyropoulou et al., 2016, 2014). The acknowledgement of its complexity necessitates the collaboration of different stakeholders to implement effective actions to prevent and reduce food waste stemming from the existence of different roles, responsibilities and levels of involvement in food system decision-making. Of all stakeholders, policymakers are key due to their important role designing public policies and plans. However, the interplay of stakeholders in the implementation of such policies and actions would suggest the need to include as wide a range of stakeholders as possible (Mourad, 2016). There is a significant body of literature from diverse domains stressing the importance of involving stakeholders in the study of complex environmental and social issues in order to approach them in a more effective way (Faysse et al., 2014; Li et al., 2017; Perveen et al., 2017; Reed, 2008). In this context, Cristóbal Garcia et al. (2016) and FAO (2015) classify stakeholders into five groups based on their role in a given food system in a region: 1) those catalysing the change (policymakers); 2) those understanding the food system (citizens and educational institutions); 3) those using policy instruments (farmers, processors, retailers, social enterprises); 4) those leveraging wider impact (NGOs, financial institutions): and 5) those learning and sharing knowledge (educational institutions, NGOs, social enterprises, researchers).

This paper seeks to address the prioritization of effective measures to prevent and reduce food waste and to examine the role of stakeholders in this. Thus, the following two questions are addressed in this paper: 1) what are the most effective measures to enhance the prevention and reduction of the food being wasted along the food supply chain; and 2) what is the role of

stakeholders in food waste prevention and reduction? To address these questions we carried out a holistic approach that comprised the participation of multiple stakeholders throughout the diverse stages of the food supply chain. The methodological framework was based on in-depth interviews and a Delphi survey. The study focused on a particular region – the Barcelona metropolitan region – which is one of the most populated areas in Europe and is located along the Mediterranean coast.

The paper contributes to the existing body of literature by providing an approach to prioritize solutions to prevent and reduce food waste in a given case study. The approach used aims at contributing to the incipient debate on how to analyse the impact of multiple and diverse alternatives of food waste prevention and reduction. This paper also offers a regional stakeholders' view on how to solve the current generation of food waste. The results are of interest to both researchers – in relation to how to propose solutions to food waste by considering the stakeholders involved – and policy bodies as it will thoroughly discuss different measures to prevent and reduce food waste that can not only be implemented in the metropolitan region of Barcelona, but also in other similar urbanized regions.

2.2.Materials and Methods

The methodological framework followed in this study (Figure 2.2.) was based on a two-stage qualitative-quantitative approach. The first stage was exploratory; it comprised in-depth interviews followed by content analysis of different stakeholders along the food supply chain. The first stage was intended to identify possible measures to prevent and reduce food waste volumes in the region along different stages of the food supply chain. The second stage consisted of a Delphi survey to explore the degree of effectiveness of preventing and reducing food waste through each of the measures identified by the interviewees in the first stage and the consensus among the stakeholders.

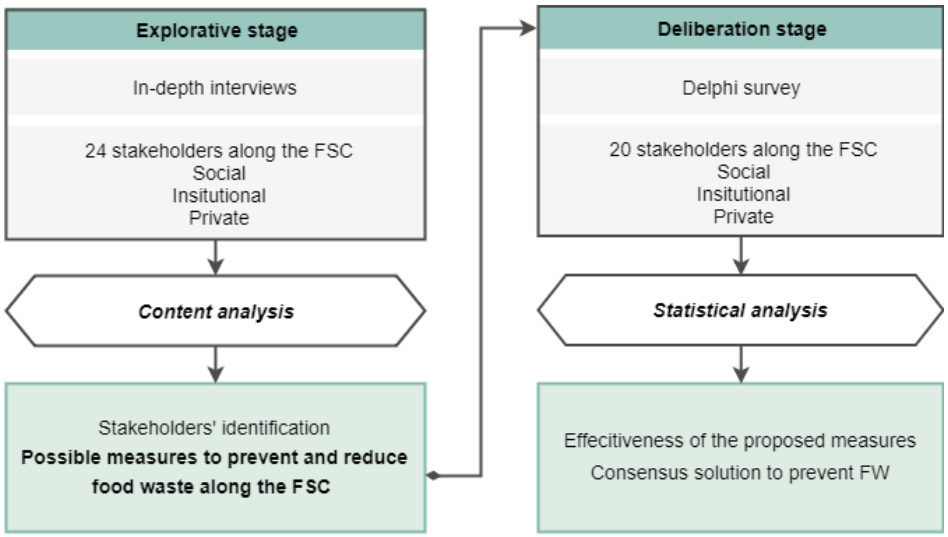


Figure 2.2. Methodological framework

2.2.1. Explorative and deliberation stage

Semi-structured interviews were conducted with 24 key stakeholders from October 2014 to January 2015 (see Table 2.1). The interview guide included different questions that ranged from general to specific. This was intended to explore different aspects of the food waste phenomenon (the causes, responsibilities, interest, knowledge and solutions). Here, we consider the last section of the interviews, which focused on exploring tentative measures to prevent and reduce food waste. The interviews lasted from 45 to 100 minutes. All the interviews were recorded and transcribed verbatim. By means of content analysis, it was possible to identify an extensive list of measures to prevent and reduce food waste that could be implemented along the food supply chain in the metropolitan region in the near future.

In the second stage, a two-round Delphi questionnaire was conducted. This stage was intended to analyse the effectiveness and the level of agreement among the panel of stakeholders on the set of measures to prevent and reduce food waste in the food chain identified in the first stage. The Delphi questionnaire was implemented in March and June of 2015 (the first round was from March to May, and the second from May to June). After the two rounds, we got answers for a final panel of 20 key stakeholders.

The Delphi method is a technique of collecting information that has been traditionally applied to forecast, exploring ideas and trends, and to reach consensus among experts on a complex issue (Kennedy, 2004). The process of obtaining results requires the participation of experts over consecutive rounds of data collection through a more or less structured (depending on the phase of the study) questionnaire. The peculiarity of this method is that the Delphi questionnaire responses from each completed round feed into the next round, which will be applied to the same consulted sample. The three key elements to take into account in the Delphi survey are: 1) the

communication between moderator and participants; 2) the continuous feedback of results; and 3) the anonymity of participants, as the opinions expressed are only presented in aggregate form (Callejo Gallego, 2009).

In our case, the participants evaluated all the identified solutions to prevent and reduce food waste using a 100-point scale (from 0, not efficient, to 100, more efficient) in the first round. The measures were grouped considering the different stages of the supply. After analysing the results from the first round, we sent the survey back to the panel. To facilitate stakeholders' comprehension and to allow them to compare their previous answers with the aggregated results of the panel, the second round survey provided the mean, the coefficient of variation and a boxplot figure. The panel again evaluated the set of measures and were able to change their previous score if they chose. We finished the Delphi survey after the second round (Gary and von der Gracht, 2015).

By analysing the final round of the Delphi questionnaire, it is possible to define the effectiveness of the measures and the level of agreement among the panel. The effectiveness of every statement was evaluated on a 0-100 continuous scale. We adapted the importance scale from Clibbens et al. (2012) to classify measures in an effectiveness scale: very high: 90-100; high: 80-89; moderate: 65-79; low: 50-64; very low: below 50. To assess the consensus about the level of agreement on specific measures, the interquartile range (IQR) was used. Consensus is reached when IQR is no larger than 20 in a scale of 100 (adapted from Gary and von der Gracht, 2015; von der Gracht, 2012). In order to highlight the divergences among stakeholders, statements with an IQR equal to or higher than 40 were underlined as dissent statements.

2.2.2. Sampling and participants

The selection of the panel of participants for the two-stage approach is key to the success of this methodological framework. Considering the complexity of the food waste phenomenon, the criterion followed to choose the participants involved enhancing heterogeneity of profiles as well as considering stakeholders along the entire food supply chain. Following Reed et al. (2009), we mapped the food system in the metropolitan region by selecting stakeholders from the private sector, public institutions and those specifically working on food waste in the social sphere. Pill (1971) suggested that the panel should comprise either experts, scholars, those interested in or those directly affected by the subject matter. We carried out an intentional sampling, which is a non-probabilistic procedure where the selection of sample units attends to subjective criteria related to the aim of the study. The key informants strategy was chosen from various options (e.g. less common case, homogeneous subgroups) (Del-Val-Cid, 2009) to select stakeholders with the maximum information about the topic. Table 2.1. shows the final panel of experts used for both stages of the study. We used the same panel from the explorative stage to form the Delphi panel.

In case we had a drop-out from a member of the first stage we tried to equilibrate the sample to keep the multi-actor approach and the heterogeneity required.

Table 2.1. Characteristics of the panel of stakeholders for the two stages of research

Participant profile	Stage		Type of stakeholder			Stage of the food supply chain								
	1: Explorative phase	2: Deliberation phase	Private	Institutional	Socially-aware	Food supply chain	Primary production	Processing	Wholesale	Retail	Redistribution	Catering	Consumers	Education
Social Enterprise "rescue" food	●	●			●	●								
Food security regional body	●	●		●		●								
Waste management regional body	●	●		●		●								
Environmental municipality	●	●		●		●								
Regional consumer body	●			●		●								
Primary production metropolitan body	●	●		●			●							
Agri-food regional body	●	●		●			●							
Farmers' organization	●			●			●							
Farmers organic cooperative	●		●				●							
Farmers' cooperative organization		●		●			●							
Industry association	●		●					●						
Industry	●		●					●						
Industry		●	●					●						
Distributor and industry		●	●					●						
Wholesaler organization	●	●	●						●					
Small wholesaler	●		●						●					
Retailer	●		●							●				
Retailer	●	●	●							●				
Retailer	●	●	●							●				
Local market body	●	●		●						●				
Wholesale retailer		●	●							●				
Charity food pantry	●	●			●						●			
Charity food bank	●	●			●						●			
Local popular dining "freegans"	●	●			●								●	
Consumer association	●	●			●								●	
Consumer association	●			●	●								●	
Expert academia	●	●			●									●
Environmental NGO	●	●			●									●

2.3.Results

The two-stage results are presented in this section. In the first stage in-depth interviews were analysed using content analysis. As a result, 48 measures to prevent and reduce food waste were identified (Table 2.2[8]). The stakeholders provided a highly diverse set of measures along the food supply chain, from those addressing particular and specific circumstances, such as the establishment of freezing protocols in supermarkets in order to increase fresh food donation to charities, to those addressing systemic aspects, such as promoting a strategic food access plan. The set of 48 measures extracted from the interviews were evaluated in the two-round Delphi

[8] Table A1 in the Appendix includes a full description of the solutions provided by the stakeholders.

panel. The results provided the stakeholder panel prioritization, as well as the degree of consensus/dissensus among them.

The perceived effectiveness of each measure in preventing and reducing the volume of food waste in the near future in the metropolitan region of Barcelona is shown in Table 2.2. This outlines the mean score for the effectiveness of each measure, the standard deviation, the medium and the IQR. In general, stakeholders assigned high values to all measures. There is no measure scoring under 50 points out of 100. The average score ranged from 57.2 to 89.4 points. The lowest valued solution was "applying a flexible mechanism to prices, offers typologies according to the production volume" (#6), while the highest valued was "education in values and valuing food and diet" (#34). Following Clibbens et al. (2012), we classified the proposed measures into three groups: 1) solutions with high effectiveness in preventing and reducing food waste (from 80 to 89 points), 2) those with moderate effectiveness (from 65 to 79 points); and 3) solutions with low effectiveness (from 50 to 64 points).

The high effectiveness group comprises seven measures aimed at increasing society's food waste concern, and improving food redistribution and access to food. Three of these focused on increasing awareness of food waste in the society, with specific emphasis on households and schools (#34, #35 and #31). Two measures proposed increasing the awareness of food waste and promoting changes in consumer habits (#29 and #30). There was also a proposal to create a strategic food access plan (#48) and to build a network to redistribute and use farm surpluses instead of wasting them (#9).

The low effectiveness group contains 11 measures. These mainly referred to the implementation of regulatory and policy changes, and improving business management. Measure number 8 suggested making the real situation of farmers more visible. Others referred to the introduction of changes in the way the food system and food redistribution is managed by incorporating price mechanisms (#6 and #43), or by planning and forecasting primary production (#1 and #3). The low effectiveness group also comprises measures in relation to regulations and policies aimed at increasing the price of waste generation (#32 and #15), and regulating and designing a network to improve the redistribution of food (#40, #18, #46 and #39).

The medium effectiveness group is the biggest one, comprising the remaining 30 measures. Measures are diverse, focusing on both specific stages of the food supply chain and those along the entire supply chain.

Apart from the panel's perceived effectiveness of the set of measures, we were also interested in the degree of agreement among them. The last column of Table 2.2 shows the IQR of each

measure; consensus[9] was reached in 15 measures. These were mostly focused on increasing society's awareness of food waste, as well as promoting changes in business dynamics. Six solutions were related to encouraging a change in habits in the society and, more specifically, in the consumers (#30, #26 and #29) so as to better educate and increase awareness about the food waste problem (#35 and #31), and to educate people in values related to appreciating food and diet (#34). There was also a meaningful consensus on solutions encouraging improvements or changes in business logistics and management (#10, #2, #25, #28 and #27). Finally, three measures were linked to food redistribution (#9, #36 and #21) and one that, from a global perspective, promoted supporting social movements in order to make the problem more visible, which can encourage companies and institutions to react (#33).

Concerning dissensus,[10] stakeholders significantly disagreed about the perceived efficacy of eight measures. Six of them proposed a new regulation or policy (#40, #5, #43, #15, #41 and #46), of which three were related to monetary incentives, like guaranteeing a minimum price to farmers (#5), increasing the disposal of industrial waste management prices (#15), and implementing laws to regulate prices and donations (#43); the other three aimed at increasing food donations and distribution by law, not relying on companies donating food (#46), regulating redistribution to human consumption and feed for animals (#40), and facilitating the bureaucracy of food donations from supermarkets (#41). The other two measures with a clear dissensus were: increasing social pressure to increase food donations (#42) and influencing farmers' mentality to encourage them to take advantage of the whole crop (#4).

2.4.Discussion

Food waste is a burgeoning area of research and there are still big gaps in knowledge. However, there is an increasingly agreement on the necessity of reducing the current generation of food waste. Public, private and social institutions have multiplied their efforts in this direction, generating and, to some extent, implementing, alternative measures. In most cases, measures have been adopted individually by one specific stakeholder, without assessing the potential impact on other stages. There is therefore a need for multi-actor approaches to evaluate and prioritize actions that significantly reduce the current food waste volume. This study attempts to fill this gap by focusing on a specific territory: the metropolitan region of Barcelona. To answer the two research questions mentioned in the introduction – 1) what are the most effective measures to enhance the prevention and reduction of the food being wasted along the food supply chain; and 2) what is the role of stakeholders in food waste prevention and reduction – we classified all

[9] Consensus among stakeholders if IQR≥20 following Gary and von der Gracht (2015) and von der Gracht (2012). Statements in bold in Table 2.

[10] Dissensus among stakeholders when IQR≥40. Statements in italics in Table 2.

Table 2.2. Measures to prevent and reduce food waste, Delphi results

		Stage	$\bar{x}$	*s*	*Md*	*IQR*
High efficacy	**(#34) Education in values and valuing food and diet**	**Soc.**	**89.4**	**7.1**	**90.0**	**10.0**
	(#35) Awareness campaigns to increase consumer concern	**Hh**	**87.6**	**11.1**	**90.0**	**5.5**
	(#29) Change of habits to reduce food waste volumes	**Soc.**	**87.3**	**15.8**	**90.0**	**18.5**
	(#31) School teaching on food waste	**Soc.**	**85.5**	**17.8**	**90.0**	**20.0**
	(#30) Promoting food purchase planning	**Hh**	**84.4**	**13.7**	**86.5**	**17.5**
	(#48) Promoting a strategic food access plan	FSC	81.0	16.0	80.0	30.0
	(#9) Network to redistribute and use farm surpluses	**Agr.**	**80.3**	**16.1**	**80.0**	**17.5**
Moderate efficacy	**(#21) Donation protocols compulsory to all supermarkets**	**Ret.**	**78.9**	**22.1**	**80.0**	**20.0**
	(#33) Supporting social movements to make companies react	**Soc.**	**78.4**	**15.4**	**80.0**	**20.0**
	(#36) Freezing protocols to facilitate donation	**FSC**	**77.3**	**15**	**80.0**	**18.8**
	(#24) Business adaptability to clients	Ret.	76.0	22.5	80.0	27.5
	(#22) Supermarket pick up route promoted and funded by the local administration	Ret.	76.0	21.9	80.0	27.5
	(#44) Legislative changes to promote FW prevention and food redistribution	FSC	75.8	24.3	80.0	36.3
	(#38) Aggrupation of social charities at the local level	Ch.	75.8	23.1	80.0	27.5
	(#25) Companies joint work to minimize FW	**Ret.**	**75.7**	**15.7**	**80.0**	**10.0**
	(#20) Micro-donations program to minimize organic waste	Ret.	75.0	25.2	80.0	37.5
	(#13) Surpluses out of best before date to food banks	Ind.	74.7	25.2	80.0	30.0
	(#11) New category commercialization regulations	FSC	74.0	20.4	80.0	27.5
	(#47) FW prevention on waste management plans	FSC	74.0	23.5	80.0	37.5
	(#14) Voluntary actions to reduce avoidable FW	Ind.	74.0	18.2	80.0	27.5
	(#23) Guides on food security and false myths about food donation	Ret.	73.8	27.4	80.0	33.8
	(#41) Administrative facilitation of supermarket food donations	*Ret.*	*72.8*	*22.1*	*80.0*	*40.0*
	(#37) Better knowledge of charity functioning	Ret.	72.0	21.7	70.0	27.5
	(#10) FW reduction in the wholesale market management	**Who.**	**70.8**	**21.8**	**75.0**	**14.0**
	(#28) Retailer awareness of stock management	**Ret.**	**70.3**	**16.5**	**80.0**	**10.0**
	(#19) Training store staff about donation methods	Ret.	70.3	23.6	80.0	30.0
	(#17) Buying whole harvest for producers	Ag-I	70.2	18.6	70.0	25.0
	(#2) Forecasting farming linked to commercialization	**Agr.**	**67.9**	**21.2**	**70.0**	**20.0**
	(#12) Improving manufacturing processes to reintegrate product within the production line	Ind.	67.9	21.7	70.0	27.5
	(#26) Campaigns aimed at buyers	**Hh**	**67.9**	**18.3**	**70.0**	**20.0**
	(#42) Increasing social pressure to increase donations	*Soc.*	*66.8*	*25.8*	*70.0*	*40.0*
	(#27) Infrastructure improvements on food conservation	**FSC**	**66.6**	**16.2**	**70.0**	**17.5**
	(#7) Boosting local agricultural production model	FSC	66.4	26.9	70.0	37.5
	(#4) Farmers' mentality of taking advantage of the whole crop	*Agr.*	*65.9*	*24.5*	*63.0*	*40.0*
	(#45) Opening new horizons on food security	FSC	65.8	24.2	75.0	30.0
	(#16) Planning (distributors and producers) what is going to be consumed	Ag-Ret.	65.8	21.6	70.0	26.0
	(#5) Minimum profitable and promising price	*Agr.*	*65.6*	*30.2*	*71.0*	*40.0*
Low efficacy	(#1) Agriculture planning improvement to avoid surpluses	Agr.	63.6	25.0	70.0	30.0
	(#8) Making the reality of primary production known	FSC	63.2	18.6	70.0	25.0
	(#39) Network of potential donors of food	FSC	63.1	21.1	70.0	30.0
	(#46) Laws and regulations to avoid donation reliance on businessperson willingness	*FSC*	*63.0*	*31.8*	*65.0*	*65.0*
	(#3) Public bodies tracking farming forecast	Agr.	62.3	21.7	70.0	30.0
	(#18) Food redistribution with business' own transport	Ret.	62.0	30.2	70.0	30.0
	(#40) Regulation on compulsory prioritizing of redistribution over feed	*FSC*	*61.5*	*27.1*	*65.0*	*40.0*
	(#32) PAYT management system	Hh	61.2	20.4	60.0	30.0
	(#15) Increasing industrial waste disposal management prices	*Ind.*	*59.2*	*28.2*	*57.0*	*52.5*
	(#43) Laws regulating boundaries between price decreasing and donations	*FSC*	*58.2*	*27.8*	*60.0*	*47.5*
	(#6) Applying a flexible mechanism to prices	FSC	57.2	20.5	59.0	30.0

Note: (#) number of measure, see Appendix A to read the whole statement; FSC: food supply chain; Agr.: Agriculture; Ag-I: Agriculture and industry; Ind.: Industry; Ret.:retail; Hh:household; Soc.: Society; Ch.:charities, $\bar{x}$: mean; s: standard deviation; Md: median; IQR: interquartile range. In **bold**: consensus statements, in *italics*: dissensus statements

the measures included in Table 2.2 into three groups of solutions: strong prevention measures, weak prevention measures and redistribution measures. We also identified the stage of the food supply chain involved, the role of stakeholders in the implementation of the proposed measure and, finally, the geographical scope of the measure. Table 2.3 summarizes the main results, as well as identifying to what extent the suggested measures were mentioned in previous literature.

2.4.1. What are the best strategies and actions to address the current scenario and reduce the food waste generation along the food supply chain?

To answer the first research question we classified all 48 measures following Mourad's (2016) three-step food waste hierarchy (see Figure 2.1.): strong prevention solutions, weak prevention solutions and redistribution. Within each group, and to better understand the type of solutions provided by stakeholders, the nature of the measures were classified into four groups by summing up the alternative classifications suggested in previous literature (Canali et al., 2017; Göbel et al., 2015; Priefer et al., 2016; Thyberg and Tonjes, 2016): 1) technologically oriented; 2) economic and business management related; 3) regulatory and policy related; and 4) appreciation and enhancement oriented.

Overall, stakeholders proposed more prevention (30) than redistribution measures (18). Regarding prevention measures, there was a preference for weak measures (19) over strong ones (11). There was no proposed solution that could be classified as recycling. With regard to their nature, a significant proportion of the measures were either business-related (17) or regulatory and policy-oriented (16); 13 measures were aimed at increasing knowledge and awareness, and only two were technology-oriented. Table 2.3. shows the classification.

Strong prevention measures are those aimed at avoiding the generation of wasted food by adopting a broader perspective, contributing to a change in paradigm or to a collective transformation of the system (Mourad, 2016). Notwithstanding the name given to these measures, previous studies have also suggested this type of action. Betz et al. (2015) and Göbel et al. (2015) claimed there is a need to develop a new appreciation for food. Stakeholders in the metropolitan region of Barcelona considered that this could be a highly effective measure to prevent and reduce food waste. Cristóbal et al. (2017) proposed changing produce specifications so as to accept and to integrate off-grade produce into the market. Similarly, Priefer et al. (2016) suggested replacing European marketing standards related to appearance with quality criteria, as well as reviewing food safety regulations. All three measures were also suggested by our panel. However, our panel assessed them as of moderate effectiveness in preventing and reducing food waste. Mourad (2016) and Priefer et al. (2016) discussed the potential impact on food waste prevention of bringing people closer to production and finding alternative marketing channels for producers. Barcelona's stakeholders also suggested promoting local production and increasing the citizen's knowledge

about the work of local producers. However, such measures were not considered very effective ways to prevent and reduce food waste in the region. This could be explained by the fact that the Barcelona metropolitan region is a highly urbanized area where a limited number of peri-urban agricultural experiences have been developed. Finally, other studies have advocated the necessity of having a broader food policy approach to tackle food waste (Blay-Palmer et al., 2018; De Schutter, 2017; Mourad, 2016; Wunder et al., 2018), which in our case could have been partially covered by the highly effective measure of developing a new strategic food access plan.

Weak prevention solutions to food waste refer to avoiding the generation of wasted food by highlighting the implications for individuals, with a view to an optimization or an improvement of processes and/or behaviours (Mourad, 2016). Since this type of measure is not calling for a major change in current dynamics, they are easier to implement, and they have been more frequently proposed in both policy debates and previous literature than strong prevention measures. Very often, consumers are targeted in campaigns aimed at increasing their awareness of food waste, or by promoting a change in consumption patterns or food-related habits (Canali et al., 2017; Cristóbal et al., 2017; Cristóbal Garcia et al., 2016; Göbel et al., 2015; Mourad, 2016; Thyberg and Tonjes, 2016). Barcelona's stakeholders not only proposed similar solutions, but also agreed on their high effectiveness. Other economic and business management-related measures that are commonly suggested in the literature were also proposed, such as improving the manufacturing processes and the food conservation infrastructure (Cristóbal et al., 2017; Mourad, 2016; Thyberg and Tonjes, 2016). However, our panel only moderately valued these. Regarding technological solutions, previous literature has suggested measures like improving the food operators' technological infrastructure and capacity (Canali et al., 2017), adjusting packaging (Cristóbal et al., 2017) and improving food labelling (Thyberg and Tonjes, 2016). However, our panel of experts did not pay significant attention to these measures.

In relation to new regulations and policies, we found different alternatives in the literature, such as stimulating investments (Canali et al., 2017), green taxation on food waste (Cristóbal Garcia et al., 2016), or changing the EU tax regulation to encourage food waste reduction (Priefer et al., 2016), among others. Our panel of stakeholders proposed two economic incentives to reduce food waste by increasing waste management prices for companies and consumers, which was also suggested by Canali et al. (2017) and Priefer et al. (2016). It is important to note that nuances matter when proposing such solutions. Although both measures #15 and #32 have low perceived effectiveness to prevent and reduce food waste, increasing industrial waste disposal management prices generated a clear dissensus among the panel, as it did not measure implementing a PAYT system to consumers.

Redistribution of food for human consumption has not been widely considered in food waste studies. The main recommendations are related to improving the technology associated with food redistribution (transportation, storage, software) (Cristóbal et al., 2017), developing new innovative solutions (Göbel et al., 2015; Priefer et al., 2016), or promoting new regulations (Good Samaritan Law, gleaning, tax incentives) (Cristóbal et al., 2017; Cristóbal Garcia et al., 2016; Thyberg and Tonjes, 2016). These measures were not directly mentioned by the stakeholders in the metropolitan region of Barcelona, who were more in favor of regulatory measures to manage food redistribution. We observed here, again, that the framing of the measures matters when considering stakeholder perceptions. The panel agreed that establishing protocols to facilitate and make compulsory donations from supermarkets would be highly effective. However, they disagreed and considered incorporating new laws and regulations to avoid reliance on businessperson willingness to have a limited degree of effectiveness. This highlights the importance of nuance.

2.4.2. What is the role of stakeholders in food waste prevention and reduction?

Many public, private and social institutions can participate in actions to prevent and reduce food waste, as is currently happening. This participation can take different forms. Stakeholders can catalyse change, contribute to analysing and understanding the situation, use policy instruments, leverage the impact, or understand and spread knowledge (Cristóbal Garcia et al., 2016; FAO, 2015). All these profiles were considered in the stakeholder panel design. We also want to assess the role of stakeholders in the proposed measures in this case study by considering: 1) the effect of the stakeholder profile on dissensus; 2) the supply food chain stages involved in the implementation of the measures to prevent/reduce food waste; 3) the leadership required for the implementation of such measures; and 4) their geographical scope.

Concerning the role of stakeholder profile on consensus/dissensus, Figure 2.3. outlines the measures where dissensus was found. This differentiates the average score of the three types of stakeholders: institutional (public), private and socially aware. As can be observed in the boxplot, social institutions tended to provide higher average values on the effectiveness than the other two groups. Summing up, we identified dissensus due to: 1) a general disparity of opinions in all groups, such as in measure #46 about regulating food donation instead of voluntary arrangements; and 2) the contradictory opinions between the groups of stakeholders, such as in # 15 about increasing industrial waste disposal management prices. In the latter case, the implementation of such a measure would clearly affect the private sector, but should be regulated by public institutions. The overall average efficacy was 59.2 out of 100, and the IQR was 52.2. The private sector group were the ones bringing dissensus to the panel, since its perceived efficacy was valued by them at 37.1 points, while the public bodies and the social organizations valued it with 61.7 and 83.1 points respectively.

Secondly, as HLPE (2014) pointed out, it is important to differentiate where the food waste is generated and the actor responsible for this volume. Consequently, in order to implement a food waste prevention or reduction measure, we should identify not only the main stage of the food supply chain at which the reduction will take place, but also all the necessary stages and stakeholders that should be considered to make such a measure effective. In this context, Table 2.3. identifies all the stages of the food supply chain and every single measure that might play a role in implementation (i.e. primary production, wholesalers, food industry, retailers, households or redistribution). As can be observed, proposed measures would need a considerable interaction among stages to succeed, which reinforces the holistic approach used in this study.

Thirdly, once the main stages of the food supply chain affected by any specific measure have been identified, the next step is to determine what type of stakeholder (public, private or both jointly) should lead the implementation of a specific measure. These results are also shown in Table 2.3. In general, regulatory and policy measures would need to be pushed by public bodies, while economic and business-oriented solutions would involve the leadership of the private sector.

Finally, identifying the geographical scope of food waste policies is highly relevant. This study focussed on a broad city context following the City Region Food Systems proposal (GIZ et al., 2016) and the leading role that cities are taking in achieving a more sustainable food system (e.g. Milan Urban Food Pact). However, there is no doubt that in a European context, policies and regulations are established at different levels. Therefore, in Table 2.3., we identify the minimum geographical scope at which each measure should be implemented to guarantee effectiveness. Three levels were considered: the region (metropolitan area, Catalonia), the state (Spain) and Europe. In the context of a global food system, not all measures will be applicable at the regional level. However, the stakeholders highlighted the need to implement some measures at the regional level in order to be effective. In any case, based on our results, it is highly necessary to encourage coordination between the regional, national and European policies in order to succeed.

Table 2.3. Food waste implementation hierarchy

	Strong prevention	**ty**	**P**	**W**	**I**	**R**	**H**	**C**	**wh**	**le**
H E	– Educating in values and valuing food and diet **(#34*)** (Betz et al., 2015; Göbel et al., 2015)	**A**					●		I	Re
	– Promoting a strategic food access plan (#48)	**R**	●	●	●	●	●		I	St/Re
Medium efficacy	– Supporting food waste social movements to make companies react **(#33*)**	**A**			●	●	●		I	Re
	– New categories and regulations to commercialize aesthetic and size rejected produce (#11) (Cristóbal et al., 2017; Priefer et al., 2016)	**R**	●	●	●	●			I	EU
	– Boosting a local agricultural production model (#7) (Mourad, 2016; Priefer et al., 2016)	**E**	●			●	●		I	Re
	– Planning (distributors and producers) what is going to be consumed (#16)	**E**	●			●	●		P	Re
	– Opening new horizons on food security (#45) (Priefer et al., 2016)	**R**	●	●	●	●	●		I	EU
	– Price guaranteeing to farmers **(#5!)**	**R**	●						I	EU
le	– Agriculture planning improvement to avoid surpluses (#1)	**E**	●						P	Re
	– Making the reality of primary production known **(#8*)**	**A**	●	●	●	●	●		P-I	Re
	– Public monitoring of farming (#3)	**R**	●						I	St/Re

	Weak prevention	**ty**	**P**	**W**	**I**	**R**	**H**	**C**	**wh**	**le**
	– Awareness campaigns to increase consumer concern and to promote a change of habits **(#35*, #29* and #30*)** (Canali et al., 2017; Cristóbal et al., 2017; Cristóbal Garcia et al., 2016; Göbel et al., 2015; Mourad, 2016; Thyberg and Tonjes, 2016)	**A**					●		I	Re
	– School teaching on food waste **(#31*)**	**A**					●		I	Re
	– Voluntary and collaborative work among companies (#14 and #**25*)** (Canali et al., 2017; Göbel et al., 2015; Mourad, 2016)	**E**			●	●			P	St/Re
	– Including food waste prevention in waste management plans (#47)	**R**	●	●	●	●	●		I	Re
	– Production and stock management adaptation to suppliers and clients (#17, #24, **#28*** and **#2***) (Cristóbal et al., 2017; Göbel et al., 2015; Mourad, 2016; Thyberg and Tonjes, 2016)	**E**	●	●	●	●	●		P	St/Re
	– Food waste reduction plan in the wholesale market **(#10*)**	**E**		●					I-P	Re
	– Manufacturing process improvement (#12) (Cristóbal et al., 2017; Mourad, 2016)	**T**			●				P	Re
	– Campaigns aimed at buyers **(#26*)**	**A**				●	●		P	Re
	– Infrastructure improvement food conservation **(#27*)** (Cristóbal et al., 2017; Thyberg and Tonjes, 2016)	**T**				●			P	St/Re
	– Farmers' mentality of taking advantage of the whole crop **(#4!)**	**A**	●						P	Re
	– Payment for waste management (**#15!**, #32) (Canali et al., 2017; Priefer et al., 2016)	**R**		●	●	●	●		I	Re
	– Price mechanism – offers according to production (#6)	**E**	●	●	●	●	●		P	St

	Redistribution	**ty**	**P**	**W**	**I**	**R**	**H**	**C**	**who**	**level**
	– Network to redistribute and use farm surpluses **(#9*)**	**E**	●	●	●	●	●	●	I-P	Re
	– Donation protocols compulsory to all supermarkets **(#21*)**	**R**				●		●	I	St/Re
	– Aggrupation of social charities at the local level (#38)	**E**						●	I	Re
	– Legislative changes to promote FW prevention and food redistribution (#44)	**R**	●	●	●	●	●	●	I	St/Re
	– Institutional facilitation of donation (reducing bureaucracy, freezing protocols, pick up routes) (#22, **#36*** and **#41**!)	**R**	●	●	●	●	●	●	I	Re
	– Micro-donation programs in retail (#20)	**E**				●		●	P-I	Re
	– Surpluses out of best before date to food banks (#13)	**E**			●	●		●	I	St/Re
	– Guides on food security and false myths about donation (#23)	**A**	●	●	●	●		●	P-I	Re
	– Better knowledge spread of charity functioning (#37)	**A**		●	●	●		●	I	Re
	– Employee training on food donation (#19)	**A**				●			P	Re
	– Increasing social pressure to increase donations **(#42!)**	**A**					●		I	Re
	– Network of potential donors of food (#39)	**E**	●	●	●	●		●	P	Re
	– Laws and regulations to avoid donation reliance on businessperson willingness **(#46!)**	**R**	●	●	●	●			I	St/Re
	– Company transportation for food donation (#18)	**E**			●	●		●	P-I	Re
	– Regulation on compulsory prioritizing of redistribution over feed **(#40!)**	**R**	●	●	●	●			I	St/Re
	– Laws regulating boundaries between price decreasing and donations **(#43!)**	**R**	●	●	●	●			I	EU

Cat.: category; T: Technological; E: Economic and business management; R: Regulatory and policy; A: Appreciation and enhancement; P: primary production; W: wholesalers; I: food industry; R: retailers; H: households; C: redistribution charities; who: who leads it?; P: private bodies; I: Institution, public bodies; P-I: public-private collaboration; le: minimum level to be implemented (EU: Europe, St: state, Re: regional); * means consensus; ! means dissensus

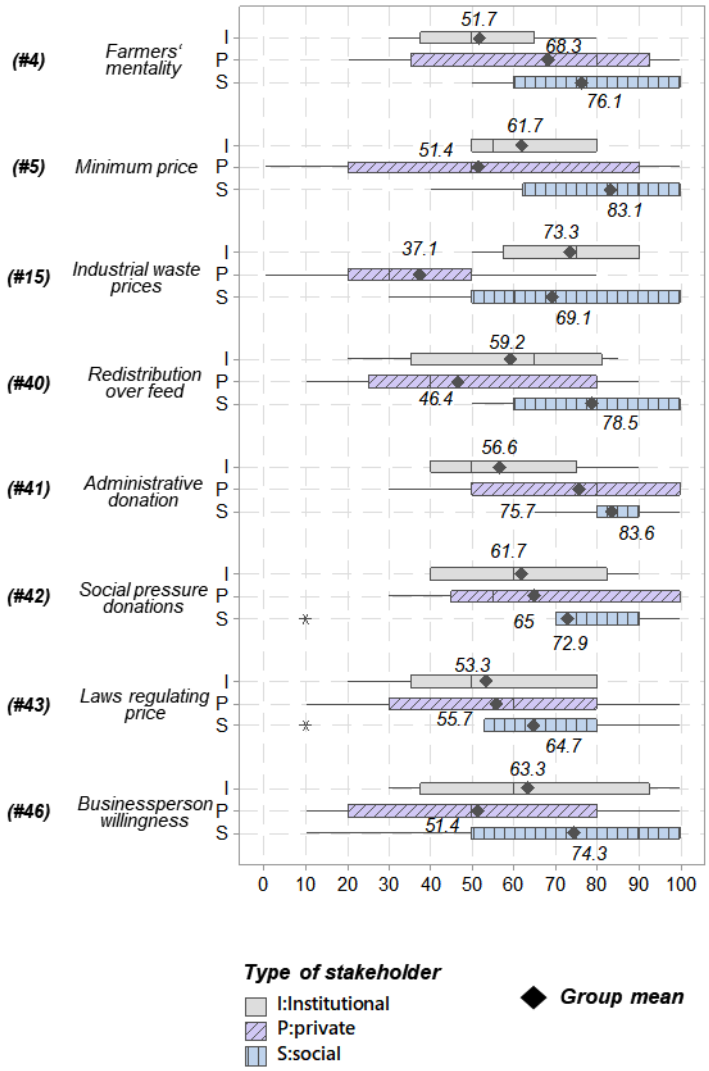


Figure 2.3. Effectiveness of dissensus measures according stakeholder profile

2.5. Conclusions

This paper has combined a holistic approach and a participatory tool to identify and prioritize measures to prevent and reduce food waste along the food supply chain. The geographical context is an urban environment larger than a single area: a city region or metropolitan area with an important peri-urban agriculture. Priorities have been assessed by combining the stakeholders' perceived effectiveness of the different measures with the degree of consensus reached among stakeholders and the hierarchy of food waste management. Policymakers should prioritize strong prevention measures where a higher effectiveness and consensus can be reached, while less priority should be given to low effective redistribution alternatives.

The results in this study suggest a number of points. First, there is a general consensus on the high effectiveness of consumer-targeted measures to increase awareness and knowledge about

food waste and its generation. On the other hand, developing new regulations and policies was perceived as not very effective, although no consensus was reached between the different types of stakeholders. More research on the impact and perception of new regulation is needed. Second, the panel of experts in this study suggested some measures to improve redistribution that had not appeared in previous literature. In this regard, further research is needed to investigate the perceived effectiveness of redistribution measures in other geographical contexts using a similar multi-actor approach. Third, it is important to highlight that the stakeholders in this study did not mention any measure aimed at gathering and generating more data on food waste volumes, which contradicts previous publications, as well as the increasing international interest on this issue. We hypothesize that this result is related to the panel composition. While in previous studies the panels were mainly composed of academics, in this study a multi-actor approach was used. More research is needed on this issue and there is no doubt about the necessity of data in the current situation.

Measures proposed by the panel were precise and extensive compared to common policy recommendations from international bodies that tend to be concise and short. Moreover, results from this study suggest that nuances and the framing of possible solutions matter since we found diverse perceived effectiveness on similar measures. Future research and policy intervention should consider this to gather future consensus and willingness to implement specific actions.

Although the results should be restricted to the metropolitan region of Barcelona, this study suggests that more research is needed to analyse stakeholders' perceived effectiveness of potential measures to prevent and reduce food waste. Similar studies should be undertaken in other geographical contexts to check if some common measures can be identified worldwide or, at least, in the European context. We found some similarities among the stakeholders' proposed measures and previous literature, but more regional studies would help to clarify the similarities.

Finally, the methodological framework used in this study, based on the combination of a participatory tool and a multi-actor approach, has proven to be effective in generating valuable insights for policymakers to define their priorities and guidelines to address the challenge of achieving the SDG's target 12.3 before 2030, as well as anticipating future conflicts when implementing specific measures.

Appendix

Table A2.1 Complete statements of food waste prevention and reduction measures

	#	
Primary production wholesalers	**1**	Agriculture planning improvement to avoid surpluses.
	2	Forecasting farming at the cooperative level linked to produce commercialization. Promoting farmers' cooperativism organization.
	3	Public bodies keeping track of farming forecast. Better knowledge of farmers' reality by means of audits with solution proposals.
	4	Farmers should have the mentality of taking advantage of everything from the crop, transforming parts of the harvest that have no other way out into preserves and looking for alternative sales channels.
	5	Guaranteeing a minimum profitable and promising price for the farmers.
	6	Applying a flexible mechanism to prices; offering typologies according to the production volume.
	7	Boosting a local agricultural production model.
	8	Making the reality of primary production known to other agents in the food chain so they will be increasingly flexible in size standards.
	9	Creating and promoting an interconnected system to redistribute and profit out of farm surpluses.
	10	Making a plan to include food waste reduction in the management of the wholesale market, direct and indirect.
	11	Including another category in the commercialization regulations to introduce products rejected due to aesthetic standards or sizes requirements into the market.
Industry	**12**	Making efforts to improve manufacturing processes to reintegrate products within the production line.
	13	Managing surpluses to send products that have surpassed the best before date to food banks.
	14	Applying voluntary actions, accompanied by the administration, to reduce avoidable food waste in the food industry.
	15	Increasing the price of industrial waste disposal management methods.
Distribution	**16**	Planning together (distributors and primary producers) what is going to be consumed each season.
	17	Industry and distributors buying whole harvest from producers and having to redistribute it to their different brand suppliers.
	18	Redistributing food suitable for consumption but not for sale to charity canteens or social entities (food pantries) with the business' own transportation.
	19	Training store staff about donation methods and protocols.
	20	Developing a micro-donations program to minimize bio-waste. Donating food suitable for consumption but not for sale, according to managers, to the closest charities to the store.
	21	Developing compulsory donation protocols for all supermarkets.
	22	Creating a pick up route through different supermarkets from a town/city to collect food for charities, promoted and funded by the local administration.
	23	Doing best practices guides and protocols together with the administration to guarantee food security and to minimize false myths about food donation and help store managers.
	24	Working inside the business planning sales and logistics by working with the historic sales data and improving the adaptation of stores to clients' typology.
	25	Different distributors and competing companies working together to find out the best ways to minimize food waste.
Small stores	**26**	Implementing campaigns aimed at buyers, together with local administrations and environmental departments to give them (buyers) anti-food waste recipes and menu planning to encourage rational purchases.
	27	Making infrastructural improvements to help with food conservation and food conservation logistics.
	28	Working on retailers' awareness to throw away as little food as possible through stock management and the use of a cold room system.
Consumers	**29**	Promoting a change of habits to reduce food waste volumes.
	30	Promoting food purchase planning.
	31	Developing school and school canteen teaching about food waste.
	32	Implementing a pay as you throw (PAYT) management system. Linking what we pay for waste management with the generation of waste.
	33	Supporting social movement organisations that are highlighting the problem of food waste because they are making companies and administrations react to the problem.
	34	Educating in values and valuing food and diet. Encouraging a safe and healthy diet because it creates responsibility and increases the valuation/appreciation of food.
	35	Implementing awareness campaigns to make the problem known and increase consumer concern.
Red	**36**	Establishing freezing protocols for fresh produce, like meat, to facilitate donation to charities.

	37	Encouraging a better knowledge of charity functioning to increase retailers and distribution companies' awareness. With trust, food redistributed increases.
	38	Promoting the aggrupation of social entities (charities/food pantries) at the local level to join efforts and improve food redistribution.
	39	Creating a network of potential producers and company donors of food.
	40	Approve regulation to make the prioritisation of food redistribution over animal feed destination compulsory.
	41	Administrative facilitation of supermarket food donation because sometimes this is bureaucratically complicated.
	42	Increasing social pressure to increase donations.
Along the FSC	**43**	Having laws to regulate the boundaries between price decreasing and donations among different actors of the supply chain.
	44	Making legislative changes to promote food waste prevention and food redistribution.
	45	Opening up new horizons concerning food security in such a way as to have a certain tolerance level with some products.
	46	Incorporating laws and regulations in such a way as food donation is not depending on businessperson willingness.
	47	Incorporating food waste prevention into waste management plans as a relevant aspect.
	48	Promoting a strategic food access plan to ensure access to equitable food and a balanced diet for all citizens.

References

Beretta, C., Stoessel, F., Baier, U., Hellweg, S., 2013. Quantifying food losses and the potential for reduction in Switzerland. Waste Manag. 33, 764–773. doi:10.1016/j.wasman.2012.11.007

Betz, A., Buchli, J., Göbel, C., Müller, C., 2015. Food waste in the Swiss food service industry – Magnitude and potential for reduction. Waste Manag. 35, 218–226. doi:10.1016/j.wasman.2014.09.015

Blay-Palmer, A., Santini, G., Dubbeling, M., Renting, H., Taguchi, M., Giordano, T., 2018. Validating the City Region Food System Approach: Enacting Inclusive, Transformational City Region Food Systems. Sustainability 10, 1680. doi:10.3390/su10051680

Brancoli, P., Rousta, K., Bolton, K., 2017. Life cycle assessment of supermarket food waste. Resour. Conserv. Recycl. 118, 39–46. doi:10.1016/j.resconrec.2016.11.024

Buzby, J.C., Hyman, J., 2012. Total and per capita value of food loss in the United States. Food Policy 37, 561–570. doi:10.1016/j.foodpol.2012.06.002

Callejo Gallego, J., 2009. Capítulo 7. El cuestionario, in: Callejo Gallego, J., del Val Cid, C., Gutiérrez Brito, J., Viedma Rojas, A. (Eds.), Introducción a Las Técnicas de Investigación Social. Editorial Universitaria Ramón Areces, Madrid, p. 336.

Campoy-Muñoz, P., Cardenete, M.A., Delgado, M.C., 2017. Economic impact assessment of food waste reduction on European countries through social accounting matrices. Resour. Conserv. Recycl. 122, 202–209. doi:10.1016/j.resconrec.2017.02.010

Canali, M., Amani, P., Aramyan, L., Gheoldus, M., Moates, G., Östergren, K., Silvennoinen, K., Waldron, K., Vittuari, M., 2017. Food waste drivers in Europe, from identification to possible interventions. Sustain. 9, 37. doi:10.3390/su9010037

Chaboud, G., 2017. Assessing food losses and waste with a methodological framework: Insights from a case study. Resour. Conserv. Recycl. 125, 188–197. doi:10.1016/j.resconrec.2017.06.008

Clibbens, N., Walters, S., Baird, W., 2012. Delphi research: issues raised by a pilot study. Nurse Res 19, 37–44. doi:10.7748/cnp.v1.i7.pg21

Cristóbal, J., Castellani, V., Manfredi, S., Sala, S., 2017. Prioritizing and optimizing sustainable measures for food waste prevention and management. Waste Manag. 72, 3–16. doi:10.1016/j.wasman.2017.11.007

Cristóbal Garcia, J., Vila, M., Giavini, M., Torres De Matos, C., Manfredi, S., 2016. Prevention of Waste in the Circular Economy: Analysis of Strategies and Identification of Sustainable Targets - The food

waste example, EUR 28422. Publications Office of the European Union, Luxembourg (Luxembourg). doi:10.2760/256208

De Schutter, O., 2017. A food policy for Europe. Green Eur. J.

Del-Val-Cid, C., 2009. Capítulo 5. La encuesta, in: Callejo Gallego, J., del Val Cid, C., Gutiérrez Brito, J., Viedma Rojas, A. (Eds.), Introducción a Las Técnicas de Investigación Social. Editorial Universitaria Ramón Areces, Madrid, p. 336.

European Commission, 2018. A monitoring framework for the circular economy, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committe of the Regions.

European Union, 2016. Combating Food Waste: an opportunity for the EU to improve the resource-efficiency of the food supply chain. Special report NO 34 (EN). European Court of Auditors (ECA) - European Union. doi:10.2865/8374

FAO, 2015. Food in an urbanised world. Rome.

FAO, 2013. Climate-Smart Agriculture Sourcebook, Sourcebook on Climate-Smart Agriculture, Forestry and Fisheries.

FAO-FAD-UNICEF-WFP and WHO, 2017. The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition. FAO, Rome.

FAO, IFAD, WFP., 2015. The State of Food Insecurity in the World: Meeting the 2015 international hunger targets: taking stock of uneven progress., FAO, IFAD and WFP. doi:I4646E/1/05.15

Faysse, N., Rinaudo, J.-D., Bento, S., Richard-Ferroudji, A., Errahj, M., Varanda, M., Imache, A., Dionnet, M., Rollin, D., Garin, P., Kuper, M., Maton, L., Montginoul, M., 2014. Participatory analysis for adaptation to climate change in Mediterranean agricultural systems: possible choices in process design. Reg. Environ. Chang. 14, 57–70. doi:10.1007/s10113-012-0362-x

Gamboa, G., Kovacic, Z., Di Masso, M., Mingorría, S., Gomiero, T., Rivera-Ferré, M., Giampietro, M., 2016. The complexity of food systems: Defining relevant attributes and indicators for the evaluation of food supply chains in Spain. Sustain. 8. doi:10.3390/su8060515

Gary, J.E., von der Gracht, H.A., 2015. The future of foresight professionals: Results from a global Delphi study. Futures 71, 132–145. doi:10.1016/j.futures.2015.03.005

GIZ, FAO, RUAF, 2016. City Region Food Systems and Food Waste Management.

Göbel, C., Langen, N., Blumenthal, A., Teitscheid, P., Ritter, G., 2015. Cutting Food Waste through Cooperation along the Food Supply Chain. Sustainability 7, 1429–1445. doi:10.3390/su7021429

Gustavsson, J., Cedeberg, C., Sonesson, U., Otterdijk, R. van, Meybeck, A., 2011. Global food losses and food waste - Extent, causes and prevention. Rome.

HLPE, 2014. Food losses and waste in the context of sustainable food systems. A Rep. by High Lev. Panel Expert. Food Secur. Nutr. Comm. World Food Secur. Rome 2014.

IPES-Food, 2016. From uniformity to diversity: A paradigm shift from industrial agriculture to diversified agroecological systems, International Panel of Experts on Sustainable Food systems. doi:IPES-Food.

Ju, M., Osako, M., Harashina, S., 2017. Food loss rate in food supply chain using material flow analysis. Waste Manag. 61, 443–454. doi:10.1016/j.wasman.2017.01.021

Kennedy, H.P., 2004. Enhancing Delphi research: methods and results. J. Adv. Nurs. 45, 504–511. doi:10.1046/j.1365-2648.2003.02933.x

Li, L., Yuan, J., Roper, K., Zhou, Z., 2017. A Multi-Stakeholder Delphi Study to Determine Key Space Management Components for Elderly Facilities in China. Sustainability 9, 1565. doi:10.3390/su9091565

Mattsson, L., Williams, H., Berghel, J., 2018. Waste of fresh fruit and vegetables at retailers in Sweden – Measuring and calculation of mass, economic cost and climate impact. Resour. Conserv. Recycl. 130, 118–126. doi:10.1016/j.resconrec.2017.10.037

Mourad, M., 2016. Recycling, recovering and preventing "food waste": competing solutions for food systems sustainability in the United States and France. J. Clean. Prod. 126, 461–477. doi:10.1016/j.jclepro.2016.03.084

MUFPP, 2017. Milan Urban Food Policy Pact 3rd Annual Gathering and Mayor Summit Valencia, Spain.

Muriana, C., 2017. A focus on the state of the art of food waste/losses issue and suggestions for future researches. Waste Manag. 68, 557–570. doi:10.1016/j.wasman.2017.06.047

Neumayer, E., 2003. Weak Versus Strong Sustainability: Exploring the Limits of Two Opposing Paradigms.

Papargyropoulou, E., Lozano, R., Steinberger, J., Wright, N., Ujang, Z. Bin, K. Steinberger, J., Wright, N., Ujang, Z. Bin, Steinberger, J., Wright, N., Ujang, Z. Bin, 2014. The food waste hierarchy as a framework for the management of food surplus and food waste. J. Clean. Prod. 76, 106–115. doi:10.1016/j.jclepro.2014.04.020

Parizeau, K., Massow, M. von, Martin, R., 2015. Household-level dynamics of food waste production and related beliefs, attitudes, and behaviours in Guelph, Ontario. Waste Manag. 35, 207–217. doi:10.1016/j.wasman.2014.09.019

Perveen, S., Kamruzzaman, M., Yigitcanlar, T., 2017. Developing policy scenarios for sustainable urban growth management: A Delphi approach. Sustain. 9, 1787. doi:10.3390/su9101787

Pill, J., 1971. The Delphi method: Substance, context, a critique and an annotated bibliography. Socioecon. Plann. Sci. 5, 57–71. doi:10.1016/0038-0121(71)90041-3

Priefer, C., Jörissen, J., Bräutigam, K.-R., 2016. Food waste prevention in Europe - A cause-driven approach to identify the most relevant leverage points for action. Resour. Conserv. Recycl. 109, 155–165. doi:10.1016/j.resconrec.2016.03.004

Reed, M.S., 2008. Stakeholder participation for environmental management: A literature review. Biol. Conserv. 141, 2417–2431. doi:10.1016/J.BIOCON.2008.07.014

Reed, M.S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C.H., Stringer, L.C., 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. J. Environ. Manage. 90, 1933–49. doi:10.1016/j.jenvman.2009.01.001

Strotmann, C., Göbel, C., Friedrich, S., Kreyenschmidt, J., Ritter, G., Teitscheid, P., Gï¿½bel, C., Friedrich, S., Kreyenschmidt, J., Ritter, G., Teitscheid, P., 2017. A participatory approach to minimizing food waste in the food industry-A manual for managers. Sustain. 9, 1–21. doi:10.3390/su9010066

Thyberg, K.L., Tonjes, D.J., 2016. Drivers of food waste and their implications for sustainable policy development. Resour. Conserv. Recycl. 106, 110–123. doi:10.1016/j.resconrec.2015.11.016

United Nations, 2015. Transforming our world: the 2030 Agenda for Sustainable Development, General Assembley 70 session. doi:10.1007/s13398-014-0173-7.2

Vivero-Pol, L.J., 2017. Food as Commons or Commodity? Exploring the Links between Normative Valuations and Agency in Food Transition. Sustainability. doi:10.3390/su9030442

von der Gracht, H. a., 2012. Consensus measurement in Delphi studies. Review and implications for future quality assurance. Technol. Forecast. Soc. Change 79, 1525–1536. doi:10.1016/j.techfore.2012.04.013

West, P.C., Gerber, J.S., Engstrom, P.M., Mueller, N.D., Brauman, K.A., Carlson, K.M., Cassidy, E.S., Johnston, M., MacDonald, G.K., Ray, D.K., Siebert, S., 2014. Leverage points for improving global food security and the environment. Science (80-.). 345, 325–328. doi:10.1126/science.1246067

Willersinn, C., Mack, G., Mouron, P., Keiser, A., Siegrist, M., 2015. Quantity and quality of food losses along the Swiss potato supply chain: Stepwise investigation and the influence of quality standards on losses. Waste Manag. 46, 120–132. doi:10.1016/j.wasman.2015.08.033

World Resources Institute, 2016. Food Loss and Waste Accounting and Reporting Standard 160.

WRAP, n.d. Why take action: legal/policy case | WRAP UK [WWW Document]. URL http://www.wrap.org.uk/content/why-take-action-legalpolicy-case (accessed 7.15.18).

Wunder, S., McFarland, K., Hirschnitz-Garbers, M., Parfitt, J., Luyckx, K., Jarosz, D., Youhanan, L., Stenmarck, Å., Gheoldus, M., Burgos, S., Cummins, A.C., Colin, F., Mahon, P., Herpen, E. van, 2018. Food waste prevention and valorisation: relevant EU policy areas. Report of the REFRESH Project, D3.3 Review of EU policy areas with relevant impact on food waste prevention and valorization.

CHAPTER 3

Moving ahead from food-related behaviours: an alternative approach to understand household food waste generation

This paper has been published in:

Diaz-Ruiz, R., Costa-Font, M., Gil, J.M., 2018. Moving ahead from food-related behaviours: an alternative approach to understand household food waste generation. Journal of Cleaner Production 172C, 1140–1151. DOI:10.1016/j.jclepro.2017.10.148

3.1. Introduction

The Food and Agricultural Organization of the United Nations (FAO), among other institutions, reported that global limitations on food availability would exist in the upcoming years up to 2050, which, combined with current food waste, results in an unethical and unsustainable world-feeding situation. Food waste is an environmental, economic, social and food security problem (Kosseva, 2013; Stuart, 2009) that urgently needs to be addressed. The United Nations advocates for it within its Sustainable Development Goals. In particular, goal 12.3 states that "By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" (United Nations, 2015). In Europe, reducing food waste is a key area of the circular economy package (European Commission, 2017).

Some work has been done to quantify food waste. FAO's report in 2011 exposed that one-third of all food produced for human consumption is lost or wasted every year (Gustavsson et al., 2011). In Europe and North America, this equals up to 300 kg of food per capita and year along the food supply chain. Moreover, published data revealed that about 50% of the total amount of food is wasted downstream, mainly at the household level (Bio Intelligence Service, 2010b; Gustavsson et al., 2011; Katajajuuri et al., 2014; Stenmarck et al., 2016). The most recent study focused on EU-28 reports that 92 kg of food are discarded per person and year at households where approximately 60% of its volume is edible (Stenmarck et al., 2016).

Although food waste occurs along the whole supply chain, consumer food waste has been reported to be a hot spot and has received special attention. Different studies have analysed consumers' behaviour, awareness and the causes of food waste in such countries as Greece (Abeliotis et al., 2014), Canada (Parizeau et al., 2015), Romania (Stefan et al., 2013), Denmark (Stancu et al., 2016), the United States (Neff et al., 2015; Qi and Roe, 2016), Italy (Principato et al., 2015; Setti et al., 2016), Singapore (Grandhi and Appaiah Singh, 2015) and New Zealand (Tucker and Farrelly, 2015). However, despite the increasing interest, the above studies use mainly food-related approaches, leaving waste-related approaches aside. Bearing in mind that the latter is the prevailing approach in food waste prevention campaigns, especially in Europe where food waste legislation is waste oriented (Lucifero, 2016), a more focused analysis on food waste prevention strategies it is necessary in order to identify individual's attitudes, values, behaviours and motivations towards wasting food. Moreover taking into account that food waste is an interdisciplinary issue, it has to be addressed from both waste and food-related perspectives (Kosseva, 2013; Langley et al., 2010). However, the magnitude of the influence of waste and food-related perspectives on consumer behaviour towards wasting food is unknown to date. The aim of the present work is to reach a better understanding of the factors that influence consumers'

food waste generation in order to define prevention strategies at the household level and demonstrate that a multidimensional perspective should be undertaken to address the prevention.

Up to date, there has been little attention on the factors driving food waste considering different behavioural dimensions simultaneously. Most of the existing academic literature on food waste either examines a partial dimension or is focused on estimating the amount of food wasted. However, consumer's food waste behaviour is a complex phenomenon build as a result of the interaction of several behavioural aspects. The decision-making process that ends on the behaviour of wasting food is shaped by social, economic and personal factors and is the outcome of the interaction of decisions, values and engagements. One of our contributions to the literature is to design a behavioural framework towards household food waste bringing together the two of the main approaches that define the food waste debate nowadays: waste management and food habits. In addition, we include consumers' values as possible predictors and moderators to complete the model. In particular, we focused on an especially significant region of Europe: the metropolitan area of Barcelona. It is one of the most populated areas of Europe located along the Mediterranean coast, with a growing population accounting for more than 3.2 million people in 2015, and it occupies an area of approximately 636 km^2, 48% of which is urbanised (AMB, 2015).

This paper is organised as follows. The next section undertakes a literature review to justify why we hypothesise that a variety of actions and motivators could affect the food waste behaviour, arguing that it is not only a food-related issue but a waste management, an environmental concern and materialistic issue, too. This section summarizes the state of the art regarding food waste behaviour at the household level and develops a conceptual model that explains consumers' food waste behaviour. Section three explains the data and method of analysis. The fourth section of the paper reports the main results of the study. Finally, the fifth section discusses the relevance of the results for further research and to define strategies of prevention food waste generation.

3.2. Theoretical framework: food waste behaviour

Previous literature demonstrate that food waste does not respond to a single behavioural dimension but emerges from a wide variety of actions and motivators (Evans, 2011; Quested et al., 2013; Secondi et al., 2015; Setti et al., 2016; UNEP, 2014). Due to its complexity, studies to date have only considered partial analysis from diverse disciplines. Watson and Meah (2012) emphasize the dichotomy between the necessity of safe and nutritious food and the desire to reduce food waste. In that line, our theoretical framework advocates for a combined approach assembling current evidences on the relevance of food and environmental behaviours as well as selected consumer values to explain consumers' food waste generation. We aim at testing the power of food-related attitudes, waste-management behaviours and selected values (environmentalism and materialism) to explain consumers' food waste behaviours.

In this section, the paper first attempts to bring together the published evidence from different studies and the distinct identified behaviours towards food waste and to develop a theoretical model considering three main issues: (i) food-related behaviours, (ii) waste management behaviours and (iii) consumers values. It is important to highlight that this research attempts to test that food waste behaviours are not only the results of food related behaviours but of a combination of food unrelated and related behaviours among other elements. Therefore, we did not focus on specific prevention or values regarding food waste, but on general waste prevention habits that we argue could be also related to the generation of food waste.

3.2.1. Food-related habits

Household food waste can be considered a food-related behaviour. Some studies intend to determine, by means of different analytical tools, the main causes of food waste generation. The most frequently identified actions that can lead to food waste generation can be grouped in five categories: food purchase, food storage, food preparation, food consumption and lifestyle related to food. Consumers' attitudes, values, knowledge and behaviour towards food might have an effect on the food waste generation (Kosseva, 2013; Parfitt et al., 2010; Principato et al., 2015). We have identified three factors related to food habits: purchasing behaviour, price importance and dietary importance as representatives of food importance towards food waste generation.

Some studies have found noticeable conceptual links between food waste and food preferences, such as nutrition and food safety (HLPE 2014), dietary conscientiousness (Parizeau et al., 2015), affection for food (Porpino et al., 2016), food preferences (Bio Intelligence Service, 2010b; Canali et al., 2014), domestic routines and habits (Evans, 2011) or the social value of food (Mallinson et al., 2016). Indeed, in the Quested et al. (2011) study, people cited eating a healthy diet as an encouraging factor for reducing food waste.

In particular, certain purchasing habits may affect the subsequent household management of food, namely poor planning and shopping routines (Mallinson et al., 2016; Mondéjar-Jiménez et al., 2015; Parizeau et al., 2015; Setti et al., 2016; Stancu et al., 2016; Stefan et al., 2013; Tucker and Farrelly, 2015), excessive buying, (Göbel et al., 2012; Parfitt et al., 2010; Porpino et al., 2015; WRAP, 2007) or the symptom of the 'good provider', who is trying to have as much variety as possible for all the household members (Graham-Rowe et al., 2014; Visschers et al., 2016).

Moreover, food price is another element which could have an influence on consumers' food waste generation. This topic has not been studied in detail but some works suggested that marketing attractions such as promotions, also named offer temptation (2x1), can alter consumer's purchase discipline (Mondéjar-Jiménez et al., 2015; Parfitt et al., 2010; Quested et al., 2013; Setti et al., 2016). Moreover, consumer during diverse focus group in Europe pointed out food prices as a possible cause of food generation in the households (Geffen et al., 2016).

Finally, Mallinson et al., (2016) described how a group of consumers who reveled higher levels of food cause were more influenced by promotions and were less price-conscious. However, besides these studies, little is known on the relationship between food price importance and food waste generation.

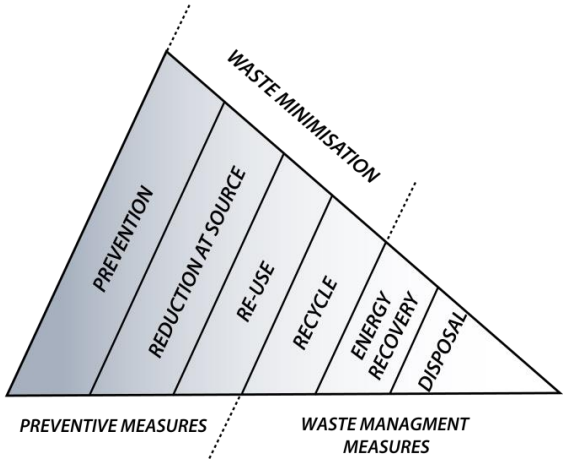
According to the aforementioned studies, we synthesize all food-related causes in three main variables, diet importance, price importance and purchasing discipline. The first three hypotheses are outlined:

- H1: Consumers who reveal a higher concern about the importance of their diet are expected to waste less food.
- H2: The importance that consumers place to food price is expected to have an influence on consumers' food waste (the effect negative or positive cannot be pre/established form the available literature)
- H3: Consumers who reveal a more disciplined purchasing behaviour are expected to waste less food.

3.2.2. Waste management

Despite the lack of specific studies on food waste behaviours connected with other waste-related activities, some food waste prevention campaigns have emerged from these specific sectors. Regulation of food waste could be characterized as recent and unspecific, even though there are some documents that highlight the urgent need for its reduction. The Waste Framework Directive (WFD-2008/98/EC) (EU, 2008) clearly defines a waste hierarchy (see Fig. 3.1) and sets a clear waste prevention procedure as a priority. Within the Waste Framework Directive, the distinction between prevention and minimisation could be misunderstood. Therefore, Figure 3.1 allocates within the waste hierarchy the different preventive measures that encompass prevention, reduction and re-use and waste management measures from recycling to disposal.

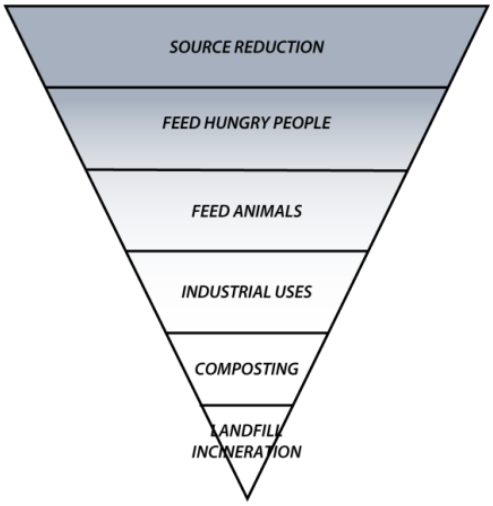
Figure 3.1. Preventive measures allocated within the waste hierarchy



Source: UE 2008/98/EC adapted to OECD EEA 2002: Case studies on waste minimisation practices in Europe

In this sense, to tackle food waste, it is important to differentiate between recycling and prevention concepts. Evidence from the UK indicates that among all strategies to prevent waste, the prevention of food waste is the one with the greatest potential (Cox et al., 2010). There is a specific food waste hierarchy (see Fig. 3.2) that transposes the hierarchy preferences to food management (European Parliament, 2011; Papargyropoulou et al., 2014).The hierarchy transposes the meanings of prevention, recycling and discarding to food. Thus, first it would be necessary to prevent the generation of food waste. Second, if waste could occur, food should be diverted to humans beforehand. Thirdly, if food cannot be reached by human consumption, it might be used to feed animals by conversion of food surplus into feeding. Next, any other industrial uses are proposed such us generation of energy, bio-energy, etc. And the last two levels of food waste recovery hierarchy are food composting and finally landfilling.

Figure 3.2. Food waste recovery hierarchy



Source: Adapted from European Parliament, (2011); Papargyropoulou et al., (2014)

There is a common tendency to relate waste reduction with recycling, although they are not the same concepts. Some examples of waste prevention are the reduction of the amount of plastic employed while shopping such as plastic bags or plastic packaging, repairing objects before buying new ones, re using glass jars, etc. Recycling actions are more commonly known such as recycling plastics, paper, etc. There is a debate in the scientific literature about the relationship between prevention and recycling behaviours. Some authors consider them to be related (Cox et al., 2010) and only the most environmentally encouraged or committed recyclers also act to prevent waste. By contrast, others suggest that waste prevention behaviours are poorly or even negatively correlated with recycling (Barr, 2007; Cecere et al., 2014; Tonglet et al., 2004b). These studies argue that recycling may become a reason for decreasing the effort to reduce waste. Moreover a recent publication found that the positive feelings of recycling can lead to using more quantity of the material needed (Sun and Trudel, 2016). Variables that influence prevention and

recycling are diverse. Some authors, such as Barr, (2007); Refsgaard and Magnussen, (2009); Tonglet et al., (2004a); Zorpas and Lasaridi, (2013) suggested that recycling behaviour is influenced primarily by opportunities, facilities and knowledge and, secondly, by not being deterred by issues of physically recycling (e.g. time, space, inconvenience). Meanwhile, the factors that influence waste prevention that are most cited in the literature are: universalism values and moral motivations, self-responsibility to act, self-efficacy, cost, social norms, habits, strong environmental values and knowledge about environmental politics (see Barr, 2007; Cox et al., 2010; Tonglet et al., 2004b). As noted by previous authors the predictors of both are totally different and are quite diverse. Therefore, we considered both behaviours to be distinguished.

Studies like Barr (2007) and Tonglet et al. (2004b) covered the issue of prevention and recycling behaviour in a global scope, without focusing on one single act as in wasting food. More recently, some studies have analysed the influence of food waste disposal, such as the use of the bio-waste container, as an explanatory variable of food waste awareness and behaviour (Tucker and Farrelly, 2015; Visschers et al., 2016).

In the present work, we characterized food waste behaviour as a specific waste management behaviour (Cecere et al. 2014). Prevention and recycling have different consequences, and we want to find out to what extend food waste is influenced by prevention and recycling behaviours.

Thus, the following two hypotheses are considered:

- H4: Consumers who reveal more positive prevention behaviour are expected to reveal lower food waste generation.
- H5: Consumers who reveal more positive recycling behaviour are expected to reveal lower food waste generation.

3.2.3. Consumers' values

Individuals' environmental concern may be an important indicator impacting food waste behaviour. In fact, recent studies have shown consumers' environmental awareness about food waste consequences (Neff et al., 2015; Principato et al., 2015). In particular, Cecere et al. (2014) indicate a positive effect of Green Attitude on the perceived production of food waste using the Eurobarometer Report of 2011[11] data. Other studies directly link environmental awareness to positive environmental behaviours and waste minimisation (Barr, 2007; Kilbourne and Pickett, 2008; Tonglet et al., 2004a). Taking into consideration the relevance of individual environmental

[11] Flash Eurobarometer 316. Attitudes of Europeans Towards Resource Efficiency

values on the formation of specific waste prevention behaviours we propose the following hypotheses to analyse its indirect and direct effect on food waste behaviour:

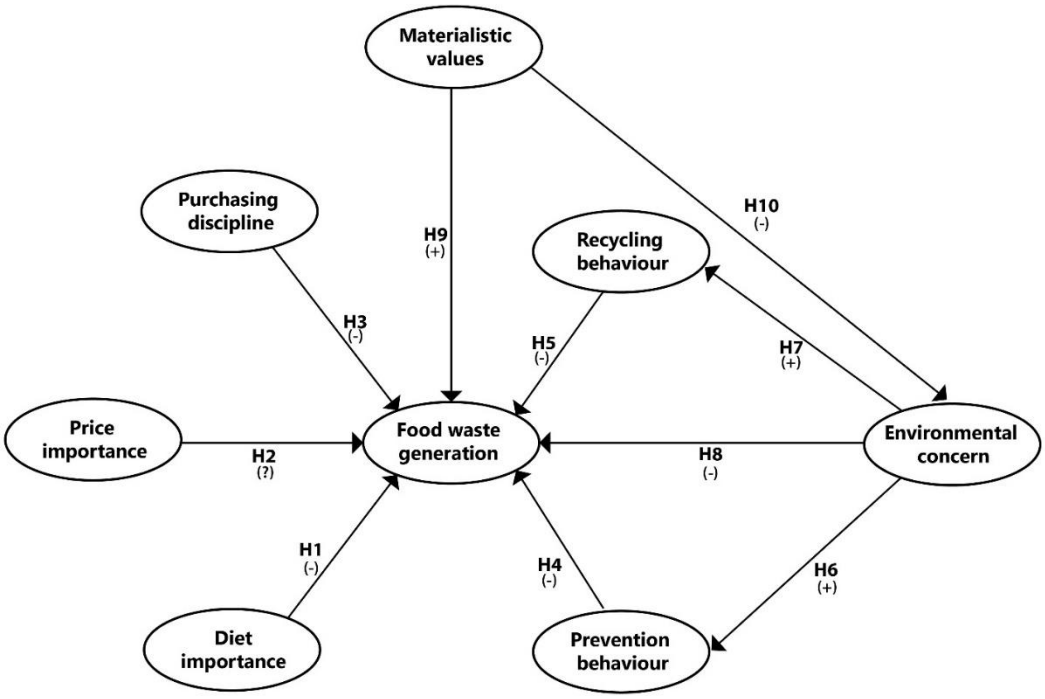
- H6: Consumers who reveal a high environmental concern are expected to demonstrate more positive waste prevention behaviour.
- H7: Consumers who reveal a high environmental concern are expected to demonstrate positive recycling behaviour.
- H8: Consumers who reveal a high environmental concern are expected to report less food waste generation

Finally, consumption habits in general could also influence food waste as mentioned by Parfitt et al. (2010) and WRAP (2007). We include in the model materialism values as a proxy of consumerism. Materialism understood as a value that attaches importance to material possessions and the pursuit of personal wealth (Richins, 2004). The relationship between materialistic values, environmental awareness and behaviour has been clearly established by previous literature. For instance, Hurst et al., (2013) estimated by means of a meta-analysis the correlation between materialism and environmental awareness, and between materialism and environmental behaviour. They noticed that materialism was negatively and equally related with both environmental awareness and environmental behaviours. Also, materialistic values were found to be negatively related to environmental beliefs, and these beliefs influence environmental awareness and environmental responsible behaviour (Kilbourne and Pickett 2008). Based on this evidence, we propose the final hypotheses for the model that states that:

- H9: Individuals' materialistic values have a negative influence on individuals' environmental awareness
- H10: Individuals' materialistic values have a negative influence on individuals' food waste behaviour.

A theoretical food-waste-values behaviour framework model has been defined (see Fig. 3.3) by taking into account all the considerations shown above. This model draws some paths of the decision-making process that consumers undertake when defining their food waste behaviour.

Figure 3.3. Theoretical framework of food waste predictors



3.3. Material and methods

3.3.1. The sample

We drew our sample from a survey conducted in the metropolitan area of Barcelona (Spain) in autumn 2013. We focused on the subset of consumers who were responsible for cooking or food purchase in their households. We distributed the survey on paper and online through different social media platforms and emails. We finally collected 418 responses. Individuals' characteristics are presented in Table 3.1 such as gender, age, area of residence, education, income and children in charge (see Table 3.1). Regarding to the implementation method, the questionnaire was, in most of the cases, self-administrated with available assistance in the case it was required (especially old people needed assistance for reading and understanding how to answer). The survey duration was of about 10 minutes. Both pencil-surveys and online form had the same format and order.

Table 3.1. Sample description

	Frequency	*% of the sample*
Gender		
Male	172	41.1
Female	246	58.9
Age >18		
18-34	179	42.8
35-49	110	26.3
50-64	102	24.4
More than 65	28	6.5
Studies		
Basics	84	20.1
Medium/superior	119	28.5
Graduate	211	50.5
Dk/na	4	1
Working status		
Employee	263	62.9
Entrepreneur	36	8.6
Pensioner	40	9.6
Unemployed	71	17.0
Dk/na	8	1.9
Housing structure		
Unipersonal	45	10.8
Couple	106	25.4
Family	234	56.0
Sharing apartment	33	7.9
Children under 16 at home		
None	292	69.9
1	69	16.5
2	37	8.9
3 or more	1	1
Dk/na	16	3.8

3.3.2. Survey and measures

The questionnaire included 44 questions to build the hypothesized model. A seven-point Likert scale was employed for all questions. Questions scales were in many cases adapted from validated scales such as environmentalism (Dunlap et al., 2000), materialism (Kilbourne and Pickett, 2008; Richins, 2004) and waste recycling and waste prevention (Barr, 2007), the remaining scales were designed by the authors based on previous experience. The final model was formed by 24 indicators due to model specifications explained below. Table 3.2 summarizes the characteristics of all latent variables and indicators included in the model. It can be observed that the model includes three constructs to capture food-related behaviours: purchasing discipline defined by two items, price importance formed by one item and finally importance of diet measured by three indicators. Two four-items constructs were considered for waste-related behaviour, recycling and prevention. Next, two dimensions represented consumer's values on materialism, which included

four items, and second environmental concern with two items. Finally, food waste generation included six items.

The survey had a short introduction[12] asking consumers participation on a food survey. Then, all Agree-Disagree questions (purchasing disciplines, price importance, diet importance, materialism values and environmental concern) were randomly presented, next waste-related questions randomly ordered and finally food waste assessment. Food waste questions were placed at end to avoid interaction between food waste questions and other behaviours under analysis. It has a specific explanation to clarify participants' responses "*Following you should think on the amount of food that you have thrown away that otherwise could have been eaten during the past month. Everything which cannot be eaten such as potatoes peels, bones, etc. are not included. You may think on the food that is thrown away through the trash bin, the organic bin, the compost or what you give to your pet."* Both online and paper survey had the same structure.

3.3.3. Analytical procedures

To test relationships among non-observed variables (latent variables) one may opt to use structural equation modelling (SEM) which is a second-generation type of modelling (Fornell and Larcker, 1981; Hair et al., 2014; Kline, 2011). There are two types of SEM, the covariance-based SEM (CBSEM) and the variance based (PLS-SEM). The former is applied to confirm or reject solid theories by estimating the covariance matrix of the data. The latter, is primarily applied in exploratory research to develop new or on early stages theories looking into the variance in the dependent variables (Hair et al., 2014). PLS intends to test how the theory fits the data, the fit of the model in PLS-SEM test the discrepancy between the observed values and the values predicted by the model in question. The objective of PLS is to maximize the variance explained rather than the fit. Due to the novelty approach of combining waste-related, food-related and values-related as a predictors of food waste, we used PLS-SEM to validate the hypotheses formulated above.

PLS technique is gaining adepts due to its flexibility in comparing theory and real data, soft distributional assumptions, its exploratory and prediction-oriented nature, its compatibility with model complexity and its ease of model interpretation among other. PLS can estimate a model with a large number of latent variables and indicators with small sample sizes (Chin et al., 2008). As noted by Akter et al., (2017), PLS-SEM has been used to analyse more latent variables and including more indicators per model on average than in the CBSEM. In their systematic review, they found that CBSEM accounted for 4.4. latent variables and 14 indicators, whereas PLS 8.12

[12] Good morning/good afternoon. My name is Raquel Diaz, I am student from the Polytechnic University of Catalonia. We are doing an investigation about food in the metropolitan area. We guarantee complete anonymity of your responses. It would take you around 10 minutes. Could you please collaborate with the study? We appreciate your participation.

latent variables and 27.42 indicators were included. PLS also gives the flexibility to include one-single item latent variables, it has no a restriction of at least three-items per latent as in CBSEM.

To assess the validity of the model, a two-stage analytical procedure is used. First, the assessment of the measurement model to evaluate the correctness of the latent variables and indicators. And, secondly the structural model relationships and predictive power. Contrary to the CB-SEM, where the two stages are consecutive, the PLS-SEM uses the complete model with the relationships between latent variables from the beginning.

Smart PLS (v.3.2.6.) (Ringle et al., 2015) was used to deduce the model. In the following section all the stages and validation statistics are explained in detailed.

3.4. Results

3.4.1. Descriptive results

The first part of this section provides some descriptive results of the different constructs considered in the model. Table 3.2 summarizes the characteristics of the indicators included in the model, reporting the statements, its mean and standard deviation (SD) as well as the frequency of response distribution within the 7-point Likert scale. These responses have been grouped in three levels: negative from 1-3, neutral 4 and positive form 5-7. We tested the normality of all indicators by means of the Saphiro-Wilk test confirming the non-normal distribution (p-value =0.000) of all observed variables.

Regarding to food related behaviours, respondents revealed to have a disciplined attitude during shopping. In fact, 60.3 % declared they 'buy only what they need' and they 'do a shopping list' (67.2%). Consuming cheap food is important for almost half of the sample (52.2%) and diet seemed to be important in their food choices. Above the 70% of the sample showed interest in eating food 'rich in vitamins' (74.2%), 'low fat food' (70.8%) and 'food free of potential hazardous ingredients' (80.4%).

Regarding to waste recycling and prevention habits, the sample affirmed to have a very high recycling and prevention behaviour. For instance, 82% of the households do recycle glass, this percentage decreased to 80%, 70% and 60% in the case of domestic packaging, paper and organic waste, respectively. In terms of waste prevention, both reusing and reduction were included on the survey. The most frequent reusing activity, that 82.3% of respondents declared to do often or always, was trying to repair things before buying new items as well as reusing paper. On reduction activities the most frequent one was using their own shopping bag.

With respect to values, respondents reported low materialism values and high environmental concern. Indeed, they most likely tend to disagree on being happier buying more things or acquiring possessions as a sign of achieving. Furthermore, 75% of the sample do not agree on

admiring people who own expensive homes, cars and clothes. However, almost half of the sample admits that they would be happier if they owned certain things they don't. As regards environmental concern, a high percentage of respondents agree that if things continue on their present course, we will soon experience a major ecological catastrophe (76.8%). We do not observe the same consensus on the statement 'The so-called "ecological crisis" facing humankind has been greatly exaggerated' where the opinion is more divided and only half of the sample do not agree with it.

Concerning food waste generation, most of participants claimed to generate very little food waste (see Fig. 3.4). The question included the most common situations in where food can be thrown away. The situation with higher mean (2.8 out of 7) is when food has been damaged or moulded.

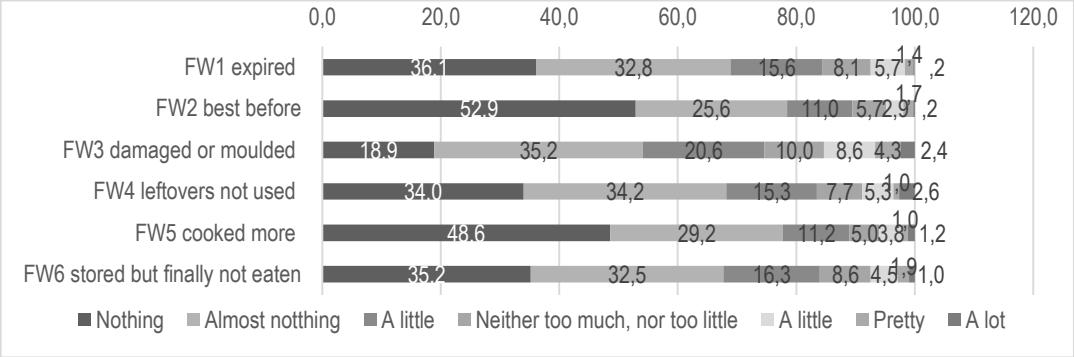


Figure 3.4 Food waste behaviour results per situation

Table 3.2 Latent variables and indicators description

		Mean	SD	Distribution within 7-point Likert scale (%)		
				1-3	4	5-7
Purchasing discipline (PUR)	***To what extend do you agree with the following statements (1 Totally disagree - 7 Totally agree)***					
PUR1	I usually buy only the things I need	4.8	1.7	25.6	14.1	60.3
PUR2	I do a shopping list with what I need when I go shopping	5.1	2.0	22.0	10.8	67.2
Price importance (PI)	***To what extend do you agree with the following statements (1 Totally disagree - 7 Totally agree)***					
PRI1	It is important to me that food I consume is cheap	4.4	1.7	27.3	20.6	52.2
Diet importance (DIET)	***To what extend do you agree with the following statements (1 Totally disagree - 7 Totally agree)***					
DIET1	Eating food rich in vitamins is important to me	5.5	1.4	8.6	17.2	74.2
DIET2	Eating low fat food is important to me	5.2	1.6	13.4	15.8	70.8
DIET3	Eating food free of potential hazardous ingredients such as pesticides is important to me	5.8	1.7	12.4	7.2	80.4
Recycling behaviour (REC)	***Could you please indicate how often do you the following? (1 Never - 7 always)***					
REC1	I recycle glass	5.9	1.9	12.4	5.0	82.5
REC2	I recycle paper	5.6	2.0	17.0	7.2	75.8
REC3	I recycle domestic packaging	5.8	1.9	13.2	6.0	80.9
REC4	I recycle organic waste	4.7	2.3	29.7	10.5	59.8
Prevention behaviour (PREV)	***Could you please indicate how often do you the following? (1 Never - 7 always)***					
RED1	I use my own bag when going shopping, rather than one provided by the shop	5.8	1.6	10.0	7.7	82.3
RED2	I buy products that can be used again, rather than disposable items	4.8	1.6	17.2	23.0	59.8
REU1	I try to repair things before buying new items	5.6	1.4	6.7	11.0	82.3
REU2	I reuse paper	5.3	1.9	16.7	9.6	73.7
Materialism values (MAT)	***To what extend do you agree with the following statements (1 Totally disagree - 7 Totally agree)***					
MAT1	My life would be better if I owned certain things I don't have	4.3	1.9	30.1	20.6	49.3
MAT2	I'd be happier if I could afford to buy more things	3.2	1.8	56.2	18.4	25.4
MAT3	I admire people who own expensive homes, cars and clothes	2.3	1.7	75.6	14.4	10.0
MAT4	Some of the most important achievements in life include acquiring possessions	3.4	1.8	52.6	18.4	28.9
Environmental concern (ENV)	***To what extend do you agree with the following statements (1 Totally disagree - 7 Totally agree)***					
ENV1	The so-called “ecological crisis” facing humankind has been greatly exaggerated (R)	4.8	1.9	24.9	16.5	58.6
ENV2	If things continue on their present course, we will soon experience a major ecological catastrophe	5.5	1.5	11.2	12.0	76.8
Food waste generation (FW)	***The amount of food I have thrown away in a recent week because ...(1 Nothing - 7 A lot)***					
FW1	it has expired is …	2.2	1.3	84.4	8.1	7.4
FW2	it has passed the best before date is...	1.9	1.2	89.5	5.7	4.8
FW3	it has been damaged or moulded such as stale bread, etc. is ... (stored in the fridge or cupboards)	2.8	1.5	74.6	10.0	15.3
FW4	I have leftovers and I have not used them for another meal is ...	2.3	1.4	83.5	7.7	8.9
FW5	I cooked more than I needed and I have not used it for another meal is….	1.9	1.3	89.0	5.0	6.0
FW6	I had stored from previous meals but finally I have not eaten is...	2.2	1.3	84.0	8.6	7.4

3.4.2. Measurement model evaluation

The measurement model was validated following the recommendations of (Hair et al., 2014). There are three main stages to do so: the assessment of item reliability, the convergent validity and the discriminant validity. The model consisted on 26 observed variables (OV) forming eight latent variables (LV). The OV excluded from the model did not accomplish the requirements.

3.4.2.1. Item reliability

According to the results showed in Table 3.3, all latent variables' composite reliability (CR) values are above 0.7 which indicates good internal consistency reliability (Fornell and Larcker, 1981). We opted to rely only on the composite reliability as a measure of the internal consistency, to the detriment of the Cronbach's alpha. Cronbach's alpha tends to underestimate the internal consistency and is sensitive to the number of items involved as well as to the sample measure (Hair et al., 2014; Xu et al., 2016). In our case, we have a wide range of LV items composition (a single-item, two items LV, etc.), that can affect the results of the statistic. Therefore, we decided to dismiss Cronbach's alpha criterion from our analysis.

3.4.2.2. Convergent validity

Convergent validity, which explains the positive correlation of a measure with alternative measures of the same construct, was tested by means of the average variance extracted (AVE). To do so, we first analyse the outer loadings of every indicator and second, we assessed the AVE's values for the LV. All indicators outer loadings are statistically significant as it is shown in Table 3.3, see t-values (the common used critical values for two-tailed test are 1.96 with 5% of significant level). In addition, most of the outer loadings are above 0.7 which means that the variance shared between the construct and the indicator is larger than the measurement error variance. There are seven outer loadings bellow that rule of thumb, however they are above 0.5. As pointed out by, Hair et al., (2014) citing Hulland, (1999) in social sciences when new scales are developed it is frequent to obtain lower outer loadings. Moreover, we have implemented the outer loading relevance testing for indicators with an outer loading below 0.7. Since the deletion of the outer loading below 0.7 has not increased the AVE and CR we decide to keep those indicators in the model. For a single-item construct (Price importance), the AVE is not an appropriate measure as the outer loading is fixed at 1.00. All of AVE are above 0.5, which indicates that the construct explains more than half of the variance of its indicators and therefore satisfies the criteria of convergent validity (Fornell and Larcker, 1981).

Table 3.3 Reliability measurements

	outer loading	*t-statistic outer loading*	*Composite Reliability*	*Average Variance Extracted (AVE)*
Purchasing discipline (PUR)			0.774	0.631
PUR1	0.818	11.056		
PUR2	0.770	8.779		
Price importance (PI)			1.000	1.000
PRI1	1.000			
Diet importance (DIET)			0.783	0.548
DIET1	0.757	4.835		
DIET2	0.803	6.356		
DIET3	0.653	4.512		
Recycling behaviour (REC)			0.936	0.786
REC1	0.916	61.966		
REC2	0.915	72.756		
REC3	0.943	101.263		
REC4	0.761	24.994		
Prevention behaviour (PREV)			0.807	0.512
RED1	0.664	12.243		
RED2	0.726	17.624		
REU1	0.720	14.021		
REU2	0.749	17.922		
Materialism values (MAT)			0.814	0.531
MAT1	0.594	6.693		
MAT2	0.849	25.824		
MAT3	0.851	24.844		
MAT4	0.572	5.719		
Environmental concern (ENV)			0.723	0.589
ENV1	0.960	13.417		
ENV2	0.506	2.459		
Food waste generation (FW)			0.888	0.572
FW1	0.641	10.379		
FW2	0.693	12.444		
FW3	0.749	19.696		
FW4	0.811	31.439		
FW5	0.807	21.314		
FW6	0.818	24.361		

3.4.2.3. Discriminant validity

As shown in Table 3.4, the discriminant validity is satisfied. We examine cross loadings of the indicators to asses to what extend every LV is different from the others, say they are measuring different things. We applied the Fornell-Larcker criterion where we compare the square root of the AVE values (in bold in the diagonal) with the latent variable correlation (off-diagonal).

We tested the possibility of having the prevention behavior break up in two dimensions measured by different constructs as proposed by Barr (2007) in the original scale. However, we detected problems of discriminant validity between them. Thus, both reusing and reducing behaviours have been considered under the same latent variable called prevention[13]. The higher

[13] A factor analysis was employed to decide if reusing and reducing behaviours can be included in a common factor. A principal component analysis was conducted on the 8 items with oblique rotation (direct oblim). The Kaiser-Meyer-

correlation found between every pair of LV was between recycling behaviour and prevention behaviour (r=0.539).

Table 3.4 Fornell-Larcker test of discriminant validity

	DIET	ENV	FW	MAT	PRE	PI	PUR	REC
DIET	**0.740**							
ENV	0.076	**0.767**						
FW	-0.144	-0.048	**0.756**					
MAT	-0.120	-0.151	0.248	**0.729**				
PRE	0.306	0.236	-0.382	-0.293	**0.715**			
PI	0.160	-0.085	0.067	0.210	-0.028	**1.000**		
PUR	0.275	0.029	-0.253	-0.157	0.336	0.096	**0.794**	
REC	0.183	0.170	-0.287	-0.288	0.539	-0.026	0.290	**0.887**

Diagonals in bold represent the square root of each construct's AVE. Off-diagonals are the latent variable correlations.

3.4.3. Structural model evaluation

Once we have established the reliability and validity of the constructs we proceed to examine the structural model which estimates hypothesized paths between exogenous and endogenous latent constructs. It was evaluated by collinearity assessment, path significance, coefficient of determination and the predictive accuracy.

The first step is to assess structural model for collinearity issues. In the proposed model there were no presence of co-linearity in the structural model since all Variance Inflation Factors are below the critical value of 5 (Hair et al., 2014).

PLS is a non-parametric technique. Thus, the bootstrapping procedure needs to be applied to obtain the significance of the paths. A 5000 sub-samples bootstrapping was applied to compute the empirical t values of the relationships in the model. Table 3.5 shows the path coefficients of all hypotheses and its t-values with the associated p-value. From the results, we can support hypotheses 4, 9 and 3. That is, there is a significant and negative association between waste prevention and food waste (path coeff. = -0.272, t-value = 4.493), a significant and positive association between materialism values and food waste (path coeff. =0.124, t-value 2.504) and finally a significant and negative association between purchasing discipline and food waste. On the contrary, hypotheses 1, 2, 5 and 8 cannot be supported. Non-significant results were found for the negative and direct association between diet importance and food waste (path coeff. = -0.011, t-value=0.216), the direct and positive association between price importance and food waste (path coeff. = 0.049, t-value=1.011), the direct and negative association between recycling behaviour

Okin measure verified the sampling adequacy for the analysis, KMO = 0.851. Two factors have eigenvalues over Kaiser's criterion of 1 and in combination explained 65.6% of the variance. The pattern matrix after rotation reveals two factors representing recycling and prevention. As regards of reduction and reusing variables it is confirmed that they are not statistically different dimensions.

and food waste (path coeff. = -0.075, t-value=1.205) and finally the direst and positive association between environmental concern and food waste (path coeff. = 0.056, t-value=1.023). With regard to other model paths, we can observe a significant relation between materialism values and environmental concern (path coeff. = -0.151, t-value=2.339) supporting hypothesis 10. Finally, environmental concern was significantly, directly and positively linked with both prevention behaviour (path coeff. = 0.236, t-value=4.383) hypothesis 6 and recycling behaviour (path coeff. = 0.170, t-value=3.229) hypothesis 7. All in all, six out of ten hypotheses were supported. Figure 3.5 presents a summary of the measurement and structural model.

Table 3.5 Significance analysis of the structural model

Hypotheses	*Path*	*Path coefficient*	*t-value*	*p-value*
H1	**DIET→FW**	-0.011	0.216	0.829
H2	**PI→FW**	0.049	1.011	0.312
H3	**PUR→FW**	-0.124	2.539	0.011
H4	**PRE→FW**	-0.272	4.450	0.000
H5	**REC→FW**	-0.075	1.205	0.228
H6	**ENV→PRE**	0.236	4.383	0.000
H7	**ENV→REC**	0.170	3.229	0.001
H8	**ENV→FW**	0.056	1.023	0.307
H9	**MAT→FW**	0.124	2.398	0.017
H10	**MAT→ENV**	-0.151	2.339	0.019

Finally, the overall potential explanatory power of food waste generation in the model equals 19.0% (R2=0.190), which is similar to the values found in previous studies analysing waste prevention behaviour (Barr, 2007; Stancu et al., 2016). Low coefficient of determination values as 0.20 can be considered high in the consumer behaviour discipline (Hair et al., 2011; Henseler et al., 2009). All coefficient of determination R^2 values of the latent constructs are shown in Table 3.6. The power in predicting the rest of exogenous LV is weak, below 6.8% of the variance explained. Yet, by examining the predictive accuracy of the endogenous constructs by means of Stone-Geisser's Q^2 value we confirmed the predictive relevance of every endogenous construct in the model (Environment concern = 0.008, Food waste = 0.090, Prevention = 0.025 and Recycling = 0.020). To assess the Q^2 values a blindfolding procedure needs to be applied (see Hair et al., (2014)for details). Values larger than zero indicate a satisfactory predictive relevance. Finally, environmental concern has a significant indirect effect towards food waste through recycling and prevention (0.077, p-value = 0.001).

Table 3.6 Coefficient of determination and predictive relevance of endogenous latent variables

	R^2	Q^2
Environmental concern (ENV)	0.023	0.008
Food waste generation (FW)	0.190	0.090
Prevention behaviour (PREV)	0.056	0.025
Recycling behaviour (REC)	0.029	0.020

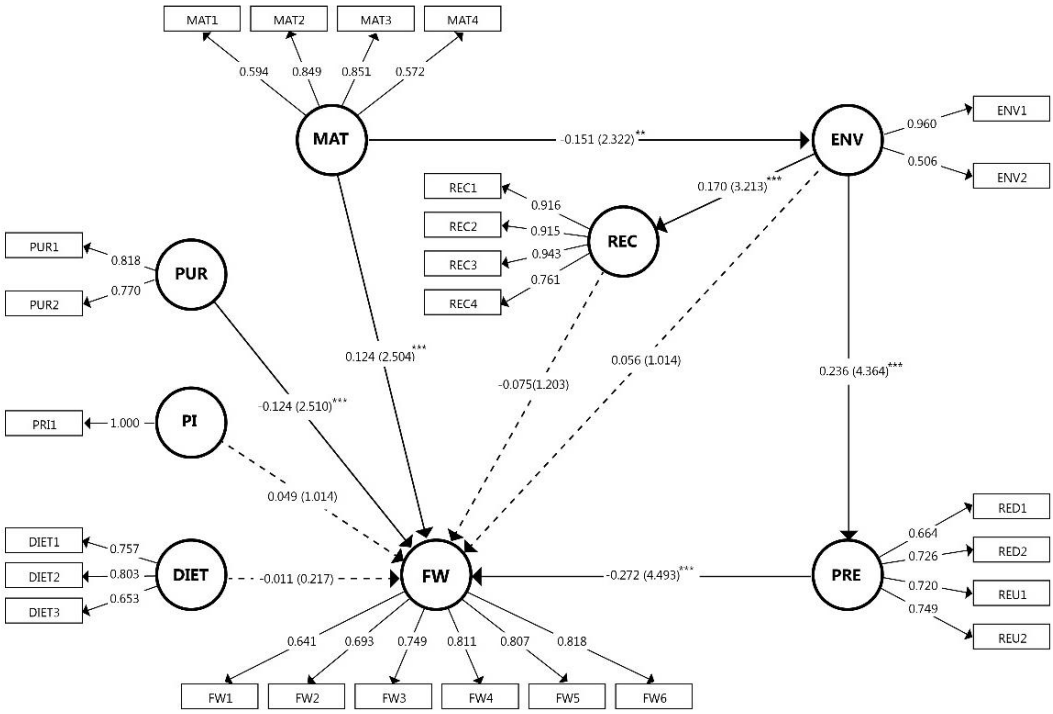


Figure 3.5 Measurement and structural model to predict consumer food waste behaviour

3.5. Discussion and conclusions

Over the past decade, many public institutions such as FAO, UN, the European commission or USDA among others together with NGOs and further stakeholders have alerted the society about the increasing amount of food being produced but not eaten. Some reports intended to quantify the amount of food lost or wasted within the different stages of the food chain reaching the conclusion that households are important points to be assessed due to the big amount of waste that they generate. In order to reduce household food waste a better understanding of the reasons that build consumers food waste behaviour is needed. Up to now a big part of the food waste literature is focused on the analysis of consumers' food attitudes to explain food waste behaviours. However, we argue that the environmental dimensions of consumers' actions together with consumer values can also play an important role in that behavioural process. To do that we

developed a model that combine food-related and waste-related behaviours together with environmental and materialism values to explain household food waste behaviours.

It is the first time, to our knowledge, that food-related and waste-related behaviours and environmental and materialism values are used in the same model to predict food waste generation. To do the analysis we employed PLS-SEM, classified as soft modelling techniques where the exploratory nature of the models prevails to the confirmatory one. The results obtained from our model confirmed our hypothesis that food waste behaviour is a complex issue that needs to be analysed with an integrative approach. Overall, the main results of the present study suggest that consumers' purchasing discipline, waste prevention behaviours and materialism values are useful direct predictors of food waste behaviour. Specifically, high and committed waste prevention behaviour influences to declare low food waste generation. Also, a disciplined purchasing behaviour – namely doing a shopping list or buying only what it is needed - also predicts lower food waste generation. Finally, the higher the materialistic values a consumer has the higher the amount of food waste he/she declares to generate. Moreover, we want to highlight that all three factors resulted equally important to predict food waste. In addition of the direct predictors indirect relations have also been identified. This is the case of environmentalism concern, that indirectly influence food waste perceived behaviour through waste prevention. Finally, we cannot assure that recycling behaviour, price and diet importance have an influence on food waste behaviour.

3.5.1. Research implications

We contribute to the literature supporting previous research mentioned in section 2 and developing a new angle for the understanding of household food waste generation. New variables considered are consumers' purchasing discipline, price importance and diet importance. We are aware that recent studies demonstrated that other food factors such as date labelling knowledge and preference, planning, marketing sale attractions or leftovers management are also important to undertint the formation of consumers' food waste behaviour. Therefore, we suggest a further analysis must be performed consider all those factors together

Another contribution refers to the recognition of a relation between high environmental concern and positive recycling behaviour contrary to previous work Barr (2007); Refsgaard and Magnussen (2009); Tonglet et al. (2004a) who noticed that individuals' recycling behaviour is not conditioned by their environmental values and does not determine their waste behaviour. With our results, we cannot ensure that recycling has a predictive effect on food waste generation. It is interesting to highlight that our model reveals a lack of differentiation between two dimensions of waste prevention behaviour that have been considered in other works as conceptually different. Waste reducing and prevention have been jointly treated in this study for three main reasons. First,

Barr, (2007), in his seminal paper, already indicated that both variables are very similar in people's mind. Second, previous research carried out in Catalonia (Díaz-Ruiz et al., 2015) corroborated this idea. Third, a discriminant analysis validated it. For future studies, it would worth it keep them separate it in order to evaluate the evolution through time. Moreover, other regions from Europe with other waste management background might have different outcomes.

This paper also contributes to the literature by relating materialism with environmentalism concern and with a specific environmental behaviour as food waste generation. The relationship between materialism and environmentalism is negative and significant confirming evidences from Hurst et al.,(2013) meta-analysis and Kilbourne and Pickett's (2008). We also tested in the same model, as recommended by Hurst et al., (2013), a direct relationship between environmentalism values and food waste generation. The relationship was positive and with almost the same intensity than towards environmental concern. These relationships are important, significant and negative, supporting Hurt et al. Moreover our model also supports the studies that relate consumerism culture life with food waste (Parfitt et al., 2010; WRAP, 2007; WRAP and Quested, 2009).

Finally, it is important to take into account that consumer behaviour is measured on a self-report basis. As seen in Figure 3.4, people tend to answer that they do not generate food waste, or only a little. Interestingly, results coincide with the answer about the amount of food wasted in the Eurobarometer Flash EB Series 316 (European Commission, 2011), in which 71% of respondents believe they throw away less than 15% (is the answer with the lowest percentage) of the food they buy. In addition, in the latest version of Euro Barometer Flash EB Series 388 (European Commission, 2014), people tend to say that they generate less food waste than in 2011. It seems that this is a general trend in consumer food waste self-reporting. In Neff et al., (2015) 73% of the sample reported that they discarded less than the average American, or, in Mondéjar-Jiménez et al., (2015), more than 75% of both groups in Italy and Spain reported that they waste none or up to 15% of the food (the second category available) that they purchased. The lack of official and cross-sectional data makes it difficult to evaluate if the estimations of consumers are correct. There is a debate on the literature between the positive and negative effects of self-reporting. On the one hand, Kormos and Gifford (2014) argue that there is a great variance (79%) between the objective behaviour and the self-reported, which remains unexplained. And, on the other hand, Milfont (2009) advocates the lack of empirical studies testing the effect of social desirability on self-reported environmental attitudes and ecological behaviour. We suggest testing different typologies of consumer food waste self-reporting and comparing those tests with real data for future studies. Improving the dependent variable variance will improve the predictive power of the models.

We encourage researchers to include variables from both perspectives, food and waste management to analyse consumers' food waste behaviour and to deepen in other cultural values such as materialism. Statistical modelling and consumers' studies have their limitations on the number of constructs we can capture from a single sample – such as the length of surveys, the cost of collecting data or the statistical performance of multiple hypotheses at the same time. However, there is a wide literature contributing to fill the gaps and improve the models. Our aim with this study was two-fold contributing to the academic literature and providing evidences to policy makers to better address food waste prevention. On the former we acknowledge the need for further empirical evidence and we encourage other researcher to include the variables proposed in the present model to their future studies, prioritizing waste prevention, shopping discipline and materialism values.

3.5.2. Policy implications

Given the urgency of the situation, structural changes need to be done to achieve significant reductions of food waste as indicated by the United Nations' SDGs. To do so, we encourage policymakers to treat the issue using a multiple dimension strategy, and involving as much expertise as possible to embrace the whole complexity of the food waste conundrum. Using this type of approach behavioural changes may be reached and last over time moving consumer to construct a more sustainable society.

We want to highlight the relevance of the prevention behaviour for food waste reduction. We perceive that prevention behaviour is a complex issue very often confused with recycling behaviours. Nevertheless, to prevent is not the same as to recycle, and the food waste prevention campaigns should address the first in order to reduce waste generation. In addition, European environmental legislation (UE 2008/98/EC) recommends to perform prevention actions as the first option in the hierarchy to manage waste, as shown in Figure 3.1, but to date it does not receive sufficient attention. As cited by the House of Lords (2014) according to FareShare[14]: 'at the moment, we have a waste hierarchy that is completely out of kilter with the economic hierarchy that sits alongside it'. It could create the temptation to prioritize energy recovery over redistribution or prevention. Researchers and policy institutions should be able to facilitate the first stages of the food waste prevention pyramid (see Fig. 3.2) by providing evidence and promoting certain regulations to encourage food waste prevention. Campaigners might be careful not to confuse consumers with the concepts of recycling, sorting or composting with prevention and not generation of waste. Sorting organic waste or composting at home could be seen as a way of being more concerned about food waste, but research on this specific topic is needed to find out the effect of food sorting.

[14] http://www.fareshare.org.uk/

In Europe, food waste prevention emerged from waste sectors. As Lucifero (2016) pointed out food waste definition in Europe is more environmentally oriented and especially waste oriented. This fact could influence food waste prevention initiatives, but our research encourages policymakers to pay greater attention to food-related variables on food waste prevention campaigns. Notwithstanding, simplifying it to mere tips on food management could be counterproductive. The results of our survey and a previous one in the same region (Díaz-Ruiz et al., 2015) revealed high self-evaluations in purchasing discipline, for example, making a shopping list, organizing the fridge or developing cooking skills. Indeed, changing prevention behaviours is not as easy as influencing recycling behaviours, as demonstrated in different studies to date. Prevention behaviours are influenced by a set of actions and values distant from materialistic or direct economic issues. Furthermore, food waste prevention, in particular, could be even more complex than other behaviours, such as energy efficiency in households. As explained by Quested et al. (2013), turning off the lights has a direct consequence, seen by the user (reducing the light bill, for instance), that food waste reduction does not have. Food waste consequences happen outside of home and could be diverse: economic, social and environmental among others. We finally recommend including the discussion of current consumerism lifestyle into the debate. And to include values-based campaigns in the food waste prevention agenda as previously proposed by other authors in the environmental field (Hurst et al., 2013). This could be translated in proposing less resources consuming lifestyles, more frugality related to decrease materialism values of individuals.

3.5.3. Final remark

To achieve the goal of reducing global food waste, special attention needs to be paid to individual households. It is necessary to understand consumers' behaviour and attitudes towards food waste generation and prevention. Since wasting food is caused by multiple factors, this paper proposes a model to encourage both researchers and policymakers to broaden the perspectives and combine a diversity of approaches to depict factors influencing the generation of food waste. And eventually, more appropriate and effective solutions will be designed.

References

Abeliotis, K., Lasaridi, K., Chroni, C., 2014. Attitudes and behaviour of Greek households regarding food waste prevention. Waste Manag. Res. 32, 237–40. doi:10.1177/0734242X14521681

Akter, S., Fosso Wamba, S., Dewan, S., 2017. Why PLS-SEM is suitable for complex modelling? An empirical illustration in big data analytics quality. Prod. Plan. Control 28, 1011–1021. doi:10.1080/09537287.2016.1267411

AMB, 2012. Àrea metropolitana - URL http://www.amb.cat/s/home.html (accessed 7.21.14).

Barr, S., 2007. Factors Influencing Environmental Attitudes and Behaviors: A U.K. Case Study of Household Waste Management, Environment and Behavior. doi:10.1177/0013916505283421

Bio Intelligence Service, 2010. Preparatory Study on Food Waste Across EU 27. doi:10.2779/85947

Canali, M., Östergre, K., Amani, P., 2014. Drivers of current food waste generation , threats of future increase and opportunities for reduction. Bologna.

Cecere, G., Mancinelli, S., Mazzanti, M., 2014. Waste prevention and social preferences: the role of intrinsic and extrinsic motivations. Ecol. Econ. 107, 163–176. doi:10.1016/j.ecolecon.2014.07.007

Chin, W.W., Peterson, R.A., Brown, S.P., 2008. Structural Equation Modeling in Marketing: Some Practical Reminders. J. Mark. Theory Pract. 16, 287–298. doi:10.2753/MTP1069-6679160402

Cox, J., Giorgi, S., Sharp, V., Strange, K., Wilson, D.C., Blakey, N., 2010. Household waste prevention--a review of evidence. Waste Manag. Res. 28, 193–219. doi:10.1177/0734242X10361506

Díaz-Ruiz, R., Costa-Font, M., Gil, J.M., 2015a. A social perspective on food waste: to what extent consumers are aware of their own food waste, in: Escajedo San-Epifanio, L., De Renobales Scheifler, M. (Eds.), Envisioning a Future without Food Waste and Food Poverty. Wageningen Academic Publishers, pp. 157–164. doi:doi:10.3920/978-90-8686-820-9_18

Dunlap, R.E., Van Liere, K.D., Mertig, A.G., Jones, R.E., 2000. New Trends in Measuring Environmental Attitudes: Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale. J. Soc. Issues 56, 425–442. doi:10.1111/0022-4537.00176

EU, 2008. DIRECTIVE 2008/98/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 November 2008 Directives on waste and repealing certain. European Parliament, European Union.

European Comission, 2017. Communication from the commission to the european parliament, the council, the european economic and social committee and the committee of the regions. Closing the loop - An EU action plan for the Circular Economy COM/2015/0614 final.

European Commission, 2011. Flash Eurobarometer Series 316, Attitudes of Europeans towards resource efficiency Analytical report Attitudes of Europeans towards resource efficiency.

European Commission, 2014. Flash Eurobarometer 388 (Attitudes of Europeans Towards Waste Management and Resource Efficiency). doi:10.2779/14825

European Parliament, 2011. Report in how to avoif food wastage: strategies for a more efficient foos chain in the EU (2011/2175(INI)) Committee on Agriculture and Rural Development Rapporteur: Slavatore Caronna.

Evans, D., 2011. Blaming the consumer – once again: the social and material contexts of everyday food waste practices in some English households. Crit. Public Health 21, 429–440. doi:10.1080/09581596.2011.608797

Fornell, C., Larcker, D.F., 1981. Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. J. Mark. Res. 18, 39. doi:10.2307/3151312

Geffen, L. van, Sijtsema, S.J., Újhelyi, K., Eisenhauer, P., Diedrich, A.-C., Brumbauer, T., Díaz-Ruiz, R., López-i-Gelats, F., Reinoso Botsho, D., Winter, M. van H., Herpen, E. van, 2016. National , Qualitative insight on Household & Catering Food Waste. Wageningen, Netherlands Wageningen Univ. Econ. Res. 193.

Göbel, C., Teitscheid, P., Ritter, G., 2012. Reducing Food Waste - Identification of causes and courses of action in North. Müntser.

Graham-Rowe, E., Jessop, D.C., Sparks, P., 2014. Identifying motivations and barriers to minimising household food waste. Resour. Conserv. Recycl. 84, 15–23. doi:10.1016/j.resconrec.2013.12.005

Grandhi, B., Appaiah Singh, J., 2015. What a Waste! A Study of Food Wastage Behavior in Singapore. J. Food Prod. Mark. 22, 1–16. doi:10.1080/10454446.2014.885863

Gustavsson, J., Cedeberg, C., Sonesson, U., Otterdijk, R. van, Meybeck, A., 2011. Global food losses and food waste - Extent, causes and prevention. Rome.

Hair, J.F., Ringle, C.M., Sarstedt, M., 2011. PLS-SEM: Indeed a Silver Bullet. J. Mark. Theory Pract. 19, 139–152. doi:10.2753/MTP1069-6679190202

Hair, J.F.J., Hult, G.T.M., Ringle, C., Sarstedt, M., 2014. A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM), Long Range Planning. doi:10.1016/j.lrp.2013.01.002

Henseler, J., Ringle, C.M., Sinkovics, R.R., 2009. The use of Partial Least Squares Path Modeling in International Marketing. Adv. Int. Mark. 20, 277–319. doi:10.1016/0167-8116(92)90003-4

HLPE, 2014. Food losses and waste in the context of sustainable food systems. A Rep. by High Lev. Panel Expert. Food Secur. Nutr. Comm. World Food Secur. Rome 2014.

House of Lords, 2014. Counting the cost of food waste: EU food waste prevention. House of Lords, European Union Committee, 10th Report of Session 2013–14.

Hurst, M., Dittmar, H., Bond, R., Kasser, T., 2013. The relationship between materialistic values and environmental attitudes and behaviors: A meta-analysis. J. Environ. Psychol. 36, 257–269. doi:10.1016/j.jenvp.2013.09.003

Katajajuuri, J.-M., Silvennoinen, K., Hartikainen, H., Heikkilä, L., Reinikainen, A., 2014. Food waste in the Finnish food chain. J. Clean. Prod. 73, 322–329. doi:10.1016/j.jclepro.2013.12.057

Kilbourne, W., Pickett, G., 2008. How materialism affects environmental beliefs, concern, and environmentally responsible behavior. J. Bus. Res. 61, 885–893. doi:10.1016/j.jbusres.2007.09.016

Kline, R.B., 2011. Principles and practice of structural equation modeling, Methodology in the social sciences. doi:10.1038/156278a0

Kormos, C., Gifford, R., 2014. The validity of self-report measures of proenvironmental behavior: Ameta-analytic review. J. Environ. Psychol. 40, 359–371. doi:10.1016/j.jenvp.2014.09.003

Kosseva, M.R., 2013. Introduction: Causes and Challenges of Food Wastage, in: Food Industry Wastes. Assessment and Recuperation of Commodities. Elsevier, pp. xv–xxiv. doi:10.1016/B978-0-12-391921-2.00019-6

Langley, J., Yoxall, A., Heppell, G., Rodriguez, E.M., Bradbury, S., Lewis, R., Luxmoore, J., Hodzic, A., Rowson, J., 2010. Food for thought?--A UK pilot study testing a methodology for compositional domestic food waste analysis. Waste Manag. Res. 28, 220–227. doi:10.1177/0734242X08095348

Lucifero, N., 2016. Food Loss and Waste in the EU Law between Sustainability of Well-being and the Implications on Food System and on Environment. Agric. Agric. Sci. Procedia 8, 282–289. doi:10.1016/j.aaspro.2016.02.022

Mallinson, L.J., Russell, J.M., Barker, M.E., 2016. Attitudes and behaviour towards convenience food and food waste in the United Kingdom. Appetite 103, 17–28. doi:10.1016/j.appet.2016.03.017

Milfont, T.L., 2009. The effects of social desirability on self-reported environmental attitudes and ecological behaviour. Environmentalist 29, 263–269. doi:10.1007/s10669-008-9192-2

Mondéjar-Jiménez, J.A., Ferrari, G., Secondi, L., Principato, L., 2015. From the table to waste: An exploratory study on behaviour towards food waste of Spanish and Italian youths. J. Clean. Prod. 138, 8–18. doi:10.1016/j.jclepro.2016.06.018

Neff, R. a., Spiker, M.L., Truant, P.L., 2015. Wasted Food: U.S. Consumers' Reported Awareness, Attitudes, and Behaviors. PLoS One 10, e0127881. doi:10.1371/journal.pone.0127881

Papargyropoulou, E., Lozano, R., K. Steinberger, J., Wright, N., Ujang, Z. Bin, Steinberger, J., Wright, N., Ujang, Z. Bin, 2014. The food waste hierarchy as a framework for the management of food surplus and food waste. J. Clean. Prod. 76, 106–115. doi:10.1016/j.jclepro.2014.04.020

Parfitt, J., Barthel, M., Macnaughton, S., 2010. Food waste within food supply chains: quantification and potential for change to 2050. Philos. Trans. R. Soc. Lond. B. Biol. Sci. 365, 3065–81. doi:10.1098/rstb.2010.0126

Parizeau, K., Massow, M. von, Martin, R., von Massow, M., Martin, R., 2015. Household-level dynamics of food waste production and related beliefs, attitudes, and behaviours in Guelph, Ontario. Waste Manag. 35, 207–217. doi:10.1016/j.wasman.2014.09.019

Porpino, G., Parente, J., Wansink, B., 2015. Food waste paradox: antecedents of food disposal in low income households. Int. J. Consum. Stud. 39, 619–629. doi:10.1111/ijcs.12207

Porpino, G., Wansink, B., Parente, J.G., 2016. Wasted Positive Intentions: The Role of Affection and Abundance on Household Food Waste. J. Food Prod. Mark. 4446, Forthcoming. doi:10.1080/10454446.2015.1121433

Principato, L., Secondi, L., Pratesi, C.A., 2015. Reducing food waste: an investigation on the behaviour of Italian youths. Br. Food J. 117, 731–748. doi:10.1108/BFJ-10-2013-0314

Qi, D., Roe, B.E., 2016. Household food waste: Multivariate regression and principal components analyses of awareness and attitudes among u.s. consumers. PLoS One 11, 1–19. doi:10.1371/journal.pone.0159250

Quested, T.E., Marsh, E., Stunell, D., Parry, A.D., 2013. Spaghetti soup: The complex world of food waste behaviours. Resour. Conserv. Recycl. 79, 43–51. doi:10.1016/j.resconrec.2013.04.011

Quested, T.E., Parry, A.D., Easteal, S., Swannell, R., 2011. Food and drink waste from households in the UK. Nutr. Bull. 36, 460–467. doi:10.1111/j.1467-3010.2011.01924.x

Refsgaard, K., Magnussen, K., 2009. Household behaviour and attitudes with respect to recycling food waste--experiences from focus groups. J. Environ. Manage. 90, 760–71. doi:10.1016/j.jenvman.2008.01.018

Richins, M.L., 2004. The Material Values Scale: Measurement Properties and Development of a Short Form. J. Consum. Res. doi:10.1086/383436

Ringle, C., Wende, S., Becker, J., 2015. Ringle, Christian M., Wende, Sven, & Becker, Jan-Michael. (2015). SmartPLS 3. Bönningstedt: SmartPLS. Retrieved from http://www.smartpls.com. Retrieved from.

Secondi, L., Principato, L., Laureti, T., 2015. Household food waste behaviour in EU-27 countries: A multilevel analysis. Food Policy 56, 25–40. doi:10.1016/j.foodpol.2015.07.007

Setti, M., Falasconi, L., Segrè, A., Cusano, I., Vittuari, M., 2016. Italian consumers' income and food waste behavior. Br. Food J. Iss Br. Food J. Br. Food J. Br. Food J. 118, 1731–1746. doi:10.1108/02656710210415703

Stancu, V., Haugaard, P., Lähteenmäki, L., 2016. Determinants of consumer food waste behaviour: Two routes to food waste. Appetite 96, 7–17. doi:10.1016/j.appet.2015.08.025

Stefan, V., van Herpen, E., Tudoran, A.A., Lähteenmäki, L., L??hteenm??ki, L., 2013. Avoiding food waste by Romanian consumers: The importance of planning and shopping routines. Food Qual. Prefer. 28, 375–381. doi:10.1016/j.foodqual.2012.11.001

Stenmarck, Å., Jensen, C., Quested, T., Moates, G., 2016. Estimates of European food waste levels.

Stuart, T., 2009. Waste: Uncovering the Global Food Scandal. Penguin books, London.

Sun, M., Trudel, R., 2016. The Effect of Recycling versus Trashing on Consumption: Theory and Experimental Evidence. J. Mark. Res. doi:10.1509/jmr.15.0574

Tonglet, M., Phillips, P.S., Bates, M.P., 2004a. Determining the drivers for householder pro-environmental behaviour: Waste minimisation compared to recycling. Resour. Conserv. Recycl. 42, 27–48. doi:10.1016/j.resconrec.2004.02.001

Tonglet, M., Phillips, P.S., Read, A.D., 2004b. Using the Theory of Planned Behaviour to investigate the determinants of recycling behaviour: A case study from Brixworth, UK. Resour. Conserv. Recycl. 41, 191–214. doi:10.1016/j.resconrec.2003.11.001

Tucker, C. a., Farrelly, T., 2015. Household food waste: the implications of consumer choice in food from purchase to disposal. Local Environ. 21, 682–706. doi:10.1080/13549839.2015.1015972

UNEP, 2014. Prevention and reduction of food and drink waste in businesses and households - Guidance for governments, local authorities, businesses and other organisations, Version 1.0.

Visschers, V.H.M.M., Wickli, N., Siegrist, M., 2016. Sorting out food waste behaviour: A survey on the motivators and barriers of self-reported amounts of food waste in households. J. Environ. Psychol. 45, 66–78. doi:10.1016/j.jenvp.2015.11.007

Watson, M., Meah, A., 2012. Food, Waste And Safety: Negotiating Conflicting Social Anxieties Into The Practices Of Domestic Provisioning. Sociol. Rev. 60, 102–120. doi:10.1111/1467-954X.12040

WRAP, Programme, R., Waste, F., Report, F., WRAP, 2007. Food Behaviour Consumer Research : Quantitative Phase.

WRAP, Quested, T., 2009. Household Food and Drink Waste in the UK A report containing quantification of the amount and types of household.

Xu, D.Y., Lin, Z.Y., Gordon, M.P.R., Robinson, N.K.L., Harder, M.K., 2016. Perceived key elements of a successful residential food waste sorting program in urban apartments: stakeholder views. J. Clean. Prod. 134, 362–370. doi:10.1016/j.jclepro.2015.12.107

Zorpas, A.A., Lasaridi, K., 2013. Measuring waste prevention. Waste Manag. 33, 1047–56. doi:10.1016/j.wasman.2012.12.017

CHAPTER 4

The effect of food waste dimensions on consumers' food waste perception. Lessons learned from a survey experiment

A preliminary version of this chapter was presented in:

*Diaz-Ruiz, R. "**Consumer's food waste perception. The influence of framing on people's perception"** Presented in 7th EAAE PhD Workshop "Challenges for young agro-food and natural resource economists facing the future" Escola Superior d'Agricultura de Barcelona (ESAB), at the Polytechnic University of Catalonia November 8th – 10th, 2017*

The work presented in this chapter was designed and started during the short stay at Cornell University Charles H. Dyson School of Applied Economics and Management in the S.C. Johnson College of Bussinnes with the supervision of Dr. David R. Just. In Ithaca, New York, United States from 12th September to 11th December 2016.

4.1. Introduction

Remarkable breakthroughs in the food system in the last several decades have resulted in greater availability of nutrients and calories than ever before. Yet, disturbing evidence suggests it may be time for a reconsideration of the food system dynamics. The Food and Agriculture Organization of the United Nations (FAO) reported in 2011 that one third of the food produced is lost or wasted worldwide (Gustavsson et al., 2011). Since then, other studies have corroborated the magnitude of the problem, and food waste has come to be seen as a major challenge in achieving sustainable food systems. Food waste is a complex issue that impacts social, economic and environmental dimensions (Gustavsson et al., 2011; HLPE, 2014; Stuart, 2009; Thyberg and Tonjes, 2016).

Despite the sustained decrease in the prevalence of hunger worldwide, almost eight hundred million people still face severe food insecurity (FAO et al., 2015) and two billion people suffer from hidden hunger (lack of micronutrients) (Biodiversity International, 2014). Moreover, food waste has economic consequences throughout the food supply chain. Food waste costs consumers and companies a significant amount of money (Vogliano and Brown, 2016). Food waste is also detrimental to the environment. For instance, food systems being one of the major contributors of the environmental damage to ecosystems (P. C. West et al., 2014) either in terms of greenhouse gas emissions (Intergovernmental Panel on Climate Change, 2014) or the consumption of natural resources such as water or soil (FAO, 2013b) among others. All these point to the unsustainability of the current food system that needs urgently to be addressed. Consequently, the United Nations (UN) established a specific target (12.3) to halve food waste and reduce food loss by 2030 within the Sustainable Development Goals (SDGs) (United Nations, 2015).

All stages of the supply chain are relevant in terms of generated food waste. However, in Western countries food waste is primarily created at the consumption stage. According FAO's estimates, out of 300 kg per capita waste around 175 kg are originate with the consumer (Gustavsson et al., 2011). The United States Department of Agriculture (USDA) estimated that 31% of food is lost and wasted at the retail and consumer level–133 billion pounds in 2010 (Buzby et al., 2014). In Europe, FUSIONS (2015) project estimated total food waste along the food supply chain to be 173 kg per capita and year, 53 % of it was allocated to consumers' food waste.

All this evidence has attracted significant attention from both policy makers and researchers. Research on food waste is flourishing, especially on consumer related approaches (Xue et al., 2017) to better understand the phenomenon. However, it also opened new debates about employed approaches and methods. Numerous uncertainties exist on how to define "food waste" (Chaboud and Daviron, 2017; HLPE, 2014; Roodhuyzen et al., 2017; Xue et al., 2017), how to predict and explain behaviors (e.g. Garrone et al., 2014; Mena et al., 2011b; Parfitt et al., 2010; Parizeau et

al., 2015b; Thyberg and Tonjes, 2016), what are the best options to prevent and reduce food waste (e.g. Cristóbal et al., 2017; Mourad, 2016) and, especially, how can food waste generation be measured and wide inconsistencies within the current numbers reconciled (Bellemare et al., 2017a; Xue et al., 2017). Despite such debates, the existing data suggests the need for a major shift in waste related policy, and indeed several actions have been taken by policymakers worldwide during the last decade. Multiple policy bodies, NGO's and leading organizations such as FAO, World Resource Institute, UNEP, USDA, EPA, European Commission, WRAP, Feedback Global among others have promoted specific actions and campaigns to reduce food waste. Campaigns are mostly targeted towards consumers with the intent to raise citizen awareness of the issue.

Previous studies have demonstrated that information and framing have an effect on consumers performance and perception in many fields such as climate change perception (e.g. Deryugina and Shurchkov, 2016), political preferences surveys (e.g. Holleman et al., 2016) or the consumption of healthy foods (Just and Gabrielyan, 2016; Just and Wansink, 2014) among others. However, little is known about the performance of food waste prevention campaigns and on the effect of the specific messages used. This paper seeks to contribute to overcoming the food waste challenge by addressing the difficulty consumers face in accounting for their own food waste and by finding out the effect of the framing of the food waste issue on consumers' perception. To this end, we designed a survey experiment to measure food waste through the use of a self-report to test the effect of four potential frames for food waste on perceived household food waste. Four treatment frames were selected to align with other works in progress and the messages used in global prevention campaigns: volume of waste, money value of waste, ability to divert to address hunger and impact on the environment. The survey was implemented in the United States in December 2016.

The US is one of the two countries, along with the UK, with major number of food waste publication (Xue et al., 2017). In 2015 the USDA and EPA defined a national goal to halve food loss and waste by 2030. Several different national strategies have focused on reducing and preventing food waste generation: U.S. Food Waste Challenge, ReFED, Save the Food, among others (Dou et al., 2016).

This paper has three major contributions: 1) it measures household food waste in the US using self-reports, 2) it tests the effect of framing on consumers' self-reported food waste and 3) it tests the effect of information regarding average food waste combined with framing on consumers' perception of their own food waste. The findings are relevant both for researchers and policy makers. Our results demonstrate the importance of framing both in measuring and addressing

food waste. Moreover, we further discuss relevant communication methodologies and policy implications on how proper framing of the issue can impact consumers' willingness to change.

4.2. Measuring consumer food waste

Having an accurate estimate of consumer's food waste would improve the measurement errors and subsequently increase the accuracy of the problem solving process. Measuring food waste entails some difficulties, especially at the consumer stage (FUSIONS, 2014a; Roodhuyzen et al., 2017; Thyberg and Tonjes, 2016; Xue et al., 2017). It is notoriously difficult to obtain objective measures of food waste from a household even at an aggregate level. Moreover, self reports of food waste appear to fall prey to recall bias. Even with recent efforts to standardize the collection of food waste data (FUSIONS, 2016; World Resources Institute, 2016) applied methods as well as food waste definitions are diverse.

Consumer's food waste has been quantified using direct or indirect measurements. Approximations based on first-hand data encompass a broad range of possibilities: kitchen diary, self-reports in questionnaires and interviews, in-home observation, waste composition analysis, self-collection of in-home waste (Herpen et al., 2016). From all of them, self-reporting surveys are extensively used not only in food waste, but also in food consumption (Conforti et al., 2017; Friedman et al., 2017) and environmental behavior and perception studies (Kormos and Gifford, 2014; Milfont, 2009). A self-reporting survey has an advantage in measuring consumer behavior because of its ease of use, low cost of implementation and flexibility, the potential for having larger samples, and because it normally requires less participant efforts to answer questions compared to other strategies (Herpen et al., 2016; Kormos and Gifford, 2014).

We carried out a literature review of studies that quantified consumers' food waste at home by means of self-reporting surveys. We found ten studies from different countries in Europe, two in the US and one in New Zealand. Sample sizes range from 147 participants (Tucker and Farrelly, 2015) up to 1,403 (Setti et al., 2016). Secondi et al., (2015) uses panel data from the Eurobarometer and the sample size is 26,595 observations from Europe (EU28). As shown in Table 4.1 there is a wide disparity on how and what exactly is measured. As mentioned above the food waste metric is not exactly the same for all studies, with the comparison we notice nuances in regards to food waste concept (leftovers, edible food, food thrown away into the bin, etc.). Food waste can be a generalized food category or it can be disaggregated by food type (fruit and vegetables, meat, bread, fish, etc.). In the selection, four out of ten studies only use a generalized food category, the rest use different numbers of food categories varying from 5 up to 15. The most common time frame used in the surveys is a week, being *last week* or *an average week*. However, it is not always specified. It can be deduced that an average behavior is assumed. Surveys tend to ask about the household food waste generation rather than the individual one. All

studies shown in the table use questions with a fixed scale. Studies assess the frequency of wasting food or the quantity, or both. The quantities are given in a qualitative scale (a little, a lot, hardly any, etc.), in percentages (3%, 16% to 30%, a tenth, etc.), in volume (less than 250 g; 250–500, one to two 10 L bucket equivalents; (10–29 L per week), etc.) or using other type of scales such as comparing ones' food waste to the average consumer. We did not find any study asking the quantity of food waste in volume in an open-ended way.

4.3. The dimensions of food waste

Food waste is commonly measured as weight (mass). Yet, other dimensions and indicators are used to express its importance and impacts (HLPE, 2014). We identified four main dimensions commonly addressed in the literature: 1) volume (e.g. Buzby and Hyman, 2012; Katajajuuri et al., 2014), 2) economic (e.g. Buzby and Hyman, 2012; Nahman et al., 2012), 3) social/nutritional (e.g. Conrad et al., 2018; Hall et al., 2009; Kummu et al., 2012), and 4) environmental (e.g. Beretta et al., 2017; Heller and Keoleian, 2014).

Consumer food waste prevention campaigns intend to raise citizens' awareness on the importance of the issue. The strategies for doing so are diverse, from advertising campaigns, measuring tools or TV shows, etc. However, they normally use the same standard messages. By reviewing the communication materials of different prominent campaigns we have identified that they all communicate the food waste problem in terms of one or more of four frames:

1) In volume, food waste is always expressed in terms of mass: pounds or kg of food wasted

- "*Consumers in rich countries waste almost as much food, 222 million tons, as the entire net food production of sub-Saharan Africa"* (Think Eat Save, 2016)

2) Economic value of food wasted in euro or dollar equivalent

- *"Every year, American consumers, businesses, and farms spend $218 billion a year, or 1.3% of GDP, growing, processing, transporting, and disposing food that is never eaten."*(ReFED, 2016)

3) The social and nutritional opportunity cost of food wasted:

- "*The food currently lost or wasted in Latin America could feed 300 million people"* (FAO, 2013a)

4) Environmental damage in terms of kg of CO^2, land occupation or water consumption:

- *"The average carbon footprint of food wastage is about 500 kg CO^2 eq. per cap and per year, equivalent to 2,300 km in an average car"* (FAO, 2013a)

Table 4.1. Literature review comparison of consumer self-reporting surveys

ref	*what*	*Food categories*	*time-frame*	*per capita or per hh*	*N*	*Type of indicator*	*Scale*
(Stancu et al., 2016)	Food thrown away of what you buy and/or grow	5	in a regular week	household	1,062	Quantity / Qualitative	hardly any; less than a tenth; more than a tenth but less than a quarter
(Abeliotis et al., 2014)	food thrown away into the bin	1	(no specified)	(no specified)	231	Quantity / Qualitative	significant amounts; quite a bit; a small amount; hardly any; none
(Quested et al., 2013)	food waste	7	Thinking generally	(no specified)	multiple surveys	Quantity / Qualitative	quite a lot; a reasonable amount; some; a small amount; hardly any; none; don't eat
(Neff et al., 2015)	food waste	5	last week	household	1,010	Quantity / Qualitative + %	None; Hardly any; Some; A fair amount; A lot; We don't eat this food
(Secondi et al., 2015)	food bought wasted	1	(no specified)	(no specified)	26,595	Quantity/ %	5% or less; 6% to 15%; 16% to 30%;31% to 50%; More than 50%; Don't know; None
(Principato et al., 2015)	food wasted	1	(no specified)	by households in general	233	Quantity/ %	10%; 20%; 30%; 40%
(Stefan et al., 2013)	food waste	5	regular week	you	244	Quantity/ %	not at all; less than a tenth; more than a tenth but less than a quarter; more than a quarter but less than a half; more than a half
(Jörissen et al., 2015)	edible food waste	15	per week	"household behavior"	453/404	Quantity/volume	nothing; less than 250 g; 250–500; 500–1000; 1000–2000; and more than 2000 g
(Tucker and Farrelly, 2015)	food waste	5	weekly	household	147	Quantity/volume	one 10 L bucket equivalent (up to 10 L per week); one to two 10 L bucket equivalents; (10–29 L per week); or three or more 10 L buckets per week (30 L or more per week)
(Qi and Roe, 2016)	food waste	1	(no specified)	household	500	Quantity/other	Comparison of wasted food to other households of the same size disagree strongly; disagree somewhat; agree somewhat; agree strongly; don't know
(Visschers et al., 2016)	discarding food	11	week-month	household	796	Quantity/volume and frequency	6-7 times per week; 3-5 times per week; 1-2 times per week;2-3;times per month; about once per month; less often or never / more than 3 portions; 2-3 portions; about 1 portion; ½ portion and less or nothing (One portion was defined as one handful of food.)
(Setti et al., 2016)	leftovers	5	weekly	household	1,403	Frequency	3/4 times a week; nearly every day; 1/2 times a week ;Less than once a week; Rarely
(Langen et al., 2015)	throwing away food	6	(no specified)	(no specified)	351	Frequency	1 Never-7 very frequently

4.4. Material and methods

4.4.1. Survey development, survey sampling and implementation

We designed a survey experiment to test the effect of the four food waste frames on food waste behavior. The survey had four treatments that corresponded to the four identified frames of food waste: volume, money, meal and environment.

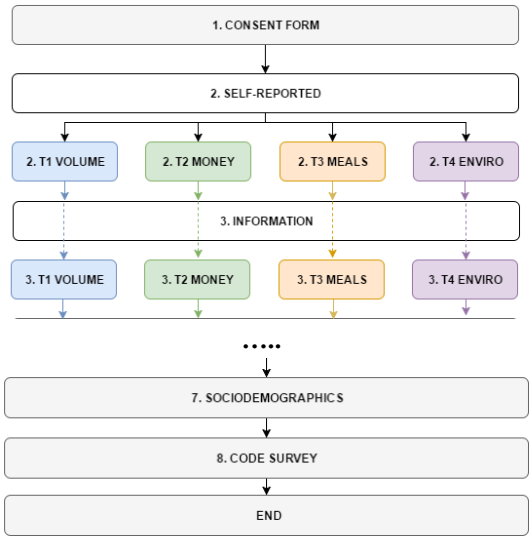
We applied a convenience survey experiment on US consumers above 18 using the Amazon Mechanical Turk (Mturk) platform from the 6th to the 8th of December 2016. Mturk is online tool that can be used for mass data collection and has its own system of recruiting participants

(Berinsky et al., 2012; Clifford et al., 2015). It is an opt-in sample, after we post the study every member of the MTurk community can see the study and decide if they want to participate. Within the universe of convenience sampling, Mturk can provide a more representative and diverse sample than other types of convenience samples used in experimental surveys (Berinsky et al., 2012). Within the Mtruk platform, members can access to the title, the duration and the economic reward of the proposed survey[15]. The length of the survey was around 15 minutes and the compensation was $1 per participant. All questions needed to be answered to receive compensation.

4.4.2. Experimental procedure-Treatments and survey

Overall, the survey had five sections covering different topics in addition to sociodemographic questions. However, for the purpose of this paper we analyse only the first two blocks of the survey: the self-quantification of food waste questions and the self-comparison to US food waste average based on information included in the survey. Both sections had four experimental framing treatments: volume (T1), money (T2), meal (T3) and environment (T4). Participants were randomly assigned to one treatment for the whole survey.

Figure 4.1. Survey structure



Within the self-quantification of food waste section, participants were asked to report their weekly household food waste for six different food categories in a given range. The food categories were 1) food in general, 2) milk and dairy products, 3) fruits and vegetables, 4) meat and fish, 5) bread and other bakery products, and 6) processed or cooked food. Participants had to move a slider along a scale that listed amounts of food waste. The midpoint of the range was

[15] The description text in Mturk: "The purpose of this study is to obtain information about consumers' responses to food practices. Participation in this study will involve answering questions on a survey. The survey should take approximately 15-20 minutes to complete."

defined using the average food waste per person per week of Buzby et al. (2014) and Heller and Keoleian (2014) (5.6 pounds, $7.1, 789 kcal and 9 kg CO^2 eq.). The slider range was adapted to each participant showing a scaled value range depending on the household size[16]. Thus, for a single-person household the values ranged from: 0 to 10 pounds in the volume treatment (Buzby et al., 2014); $0 to $15 in money treatment (Buzby et al., 2014); 0 to 14 meal equivalences in meal treatment (we assumed that 789 daily calories from Buzby et al., (2014) is equivalent to one main meal); and 0 to 18 kg CO^2 eq. for environment treatment (Heller and Keoleian, 2014). Despite all six food categories having the same range, there was a warning sentence to remind participants that the first category "Food in general" should be greater than the sum of the other specific food categories. Figure A4.1. in the Appendix shows an example of the questions as they appeared to participants. Questions were adapted for each treatment:

Volume treatment:

"Could you estimate the amount of food that is thrown away for different reasons in your household in a week? (do not consider inedible parts such as bones or peelings)."

Money treatment:

"Could you estimate the amount of money thrown away due to the food thrown away in your household in a week? (do not consider inedible parts such as bones or peelings)."

Meal treatment:

"Could you estimate the amount of meal equivalencies that have been thrown away in your household in a week? (do not consider inedible parts such as bones or peelings)"

Environment treatment:

"Could you estimate the carbon footprint generated due to the food thrown away in your household in a week? (do not consider inedible parts such as bones or peelings)"

The information effect was tested in a single question preceded by two sentences that contained food waste information. Participants had to compare their own food waste to the average US consumer answering the question: "Do you think you throw away more or less than the average American?" based in Neff et al., (2015) in a Likert scale of 7 points from far above the average (1) to far below (7)[17]. We elaborated two sentences from data of peer-reviewed publications or food waste campaigns. Each experimental condition had equivalent information:

[16] All values were scaled for every participant household member's number. For example, if a person responded that they were 3 people in his/her household in the money treatment he/she had to move the slider in a rank from $0 to $45.

[17] 1 Far above average / 2 Moderately above average / 3 Slightly above average / 4 Average / 5 Slightly below average / 6 Moderately below average / 7 Far below average

Volume treatment:

- *"In the US every citizen is wasting 5.6 pounds of edible food a week."* based in Buzby et al., (2014)
- *"20% of the food each American buys never gets eaten."* based in Save The Food, (2016)

Money treatment:

- *"In the US every citizen is wasting $7 dollars a week in edible food thrown away"* based in Buzby et al., (2014)
- *"Every year, American consumers, businesses, and farms spends $218 billion a year, or 1.3% of GDP, growing, processing, transporting, and disposing food that is never eaten."* based in ReFED, (2016)

Meal treatment:

- *"In the US every citizen is wasting enough food to feed a person 7 meals a week."* based in Buzby et al., (2014)
- *"One in seven Americans, many of them children, are food insecure without reliable access to sufficient, affordable, nutritious food."* based in Buzby et al., (2014) and Save The Food, (2016)

Environment treatment:

- *"In the US, consumers carbon footprint associated with edible food wasted during a week per person is around 9 kg CO2 eq., equivalent to driving 25.7 miles in an average car."*
- *"14% of greenhouse gases in the United States are associated with growing, manufacturing, transporting, and disposing of food."* based in Think Eat Save, (2016)

4.4.3. Ethics statement

This study and its consent procedure were reviewed and approved by Cornell's Institutional Review Board for Human Participants. The clarity and relevance of the questions were pre-tested before publishing them.

4.4.4. Analysis

Results were analysed in SPSS Version 24.0 (IBM Corp. Released, 2016). We used chi-square test of independence to test the independence of treatments with socio-demographic differences among them. ANOVA test was used to analyse the variance between different framing treatments and respondents self-reporting of food waste and self-comparison with the US food waste average.

Before implementing the corresponding analyses, the Qualtrics original data from the survey was cleaned using the following procedure. First, all non-finished and anomalous responses were deleted from the database. Moreover, a new variable was created: "Σ Food categories". It sums all specific food categories from the survey question: milk and dairy products, fruits and vegetables, meat and fish, bread and other bakery products and processed or cooked food.

To test the effect of framing in the self-reporting question it is necessary to have all treatments' variables in the same units. We considered the volume treatment (in pounds) as the reference for the other three. The conversion factors were obtained from the publications we used to design the questionnaire. Therefore, 290 pounds of food waste equals $371 (Buzby et al., 2014); 290 pounds equals 365 meals (360 grams one meal) – we assumed that 789 calories of food waste per person per day in Buzby et al., (2014) equals one main meal; and, 273 pounds equals to 511 kg CO^2 equivalent (Heller 2015). Corresponding variables for each seven questions were computed in pound-equivalents.

4.4.5. The sample

A total of 3,603 Mturkers started the survey. They were randomly assigned to one of the four treatments: volume treatment (n = 900), money treatment (n = 901), meal treatment (n = 902) and environmental treatment (n = 900). We excluded all non-finished surveys, therefore the final sample was 3,257 observations: 808 in volume, 823 in money, 837 in meals, and 789 in environment treatment. This entails a general attrition rate of 10% which varies per treatment, volume treatment (10%), money treatment (9%), meal treatment (7%) and environment treatment (12%).

Table 4.2. shows respondents demographics per treatment compared to the total sample. Overall, the sample was 57% females. Almost half of the sample (53.2%) was between 18 and 34 years old, 35% was between 35 and 54 years old, and 10.2% was above 55. Household income was distributed as follows: less than $10,000 (4.8%), from $10,000 to $20,000 (8.6%), from $20,000 to $39,999 (23.6%), from $40,000 to $59,999 (21.6%), from $60,000 to $79,999 (17.2%), from $80,000 to $99,999 (10.7%) and more than $100,000 (13.4%). Almost 30% of the sample's households were composed of two members, followed by three-member households (22.3%), single member households (18.2%) and four-member households (17.8%), and the remaining 12% of households had more than four members. The average household size was 2.8 people per household. With regard to education, 33.7% of respondents have a High School Diploma, 44.4% - a Bachelor's degree, 12.8% - a Master's degree, 2.3% a Doctorate, and the remaining 7% have other types of education. Almost half of the sample lives in suburban areas, 31.7% in urban, and 21.2% in rural areas. Respondents ethnicity was primarily white (77.4%). Fifty-eight percent of participants were employed full time, and 16.5% were part time employees. The remaining percentage was distributed among unemployed, retired, students and disabled respondents.

To assume that mean-score differences in framing treatments was not caused by sampling differences, we carried out a chi-square test with treatment indicator and sociodemographic variables. The results showed that there was a non-significant association between the type of

treatment and any of sociodemographic variables: treatment-gender $\chi 2$ (3)=1.2, p=0.75; treatment-age $\chi 2$ (15)=8.9, p=0.88; treatment-income $\chi 2$(18)= 22.4, p=0.22; treatment-education $\chi 2$ (12)=16.6, p=0.16; treatment-location $\chi 2$ (6)=3.9, p=0.68; treatment-ethnicity $\chi 2$ (15)=19.6, p=0.18; treatment-employment $\chi 2$ (18)=14.7, p=0.68.

Our sample cannot be considered representative of the US population. It is younger, there are slightly more females, and there is an underrepresentation of higher income participants, as well as Black or African American and Hispanic or Latino ethnicity origin. See Table A4.1. in the appendix for more details.

4.5. Results and discussion

4.5.1. The effect of information

Individuals were asked to compare their consumption to the average in each of the frame. They were exposed to two sentences explaining the household food waste situation in the US adapted for each of the four treatments. After reading them, they had to compare themselves with the average American food waste (below, equal or above the US average). Figure 4.2. shows the distribution of responses for each treatment. We noticed that participants, on average, reported their food waste below the average US consumer. Sixty-eight percent of respondents in the volume treatment group situated themselves below the average, 19% on the average, and 12% above the average. A similar distribution was found on the meal treatment where 69% reported throwing away less than the US average, 21% on the average and 10% above the average. The environmental group distribution was slightly shifted to the right, 63% below the average, 23% on the average and 14% above. Finally, money treatment group distribution was substantially different from the others. Now 29% of respondents declared throwing away more food than the average US consumer, 23% situated themselves on the average and less than half of the sample answered below the average.

We found a significant treatment effect on the perception of food waste compared to US average food waste, $F(3, 3253)=48.78$, $p< 0.001$, $\omega=0.21$. Post hoc comparisons using the Games-Howell test indicated that the mean score for the volume treatment (M = 2.8, SD = 1.4) was significantly different than the money treatment (M = 3.5, SD = 1.6) and environment treatment (M=3.0, SD=1.4). However, the volume treatment did not significantly differ from the meal treatment (M=2.8, SD=1.3). The money treatment differed significantly from the meal treatment and the environment treatment. Finally, meal treatment mean score differed significantly from the environment treatment (Table 4.3.).

Table 4.2. Socio demographic characteristics of the sample per treatment, Chi-square test

		Treatment				Total	Pearson Chi-square
		T1 Vol.	T2 Mon.	T3 Mea.	T4 Env.		
	Sample	*808*	*823*	*837*	*789*	*3257*	
Gender	**Female**	55.3%	57.5%	57.7%	57.4%	57.0%	0.746
	Male	44.7%	42.5%	42.3%	42.6%	43.0%	
Age mean (SD)= 36.4 (11.9)	**18-24**	13.7%	12.2%	14.1%	12.9%	13.2%	0.880
	25-34	39.2%	40.9%	42.2%	41.3%	40.9%	
	35-44	22.8%	23.6%	21.0%	23.7%	22.8%	
	45-54	14.1%	12.8%	12.4%	11.9%	12.8%	
	55-64	7.5%	8.5%	7.9%	7.0%	7.7%	
	65 or more	2.6%	2.1%	2.4%	3.2%	2.5%	
Income	**Less than $10,000**	5.8%	4.9%	4.4%	4.2%	4.8%	0.216
	$10,000- $19,999	8.3%	9.4%	9.4%	7.4%	8.6%	
	$20,000-39,999	24.5%	23.7%	21.9%	24.5%	23.6%	
	'$40,000-59,999	21.5%	20.0%	22.1%	22.8%	21.6%	
	$60,000-79,999	14.6%	19.3%	18.3%	16.5%	17.2%	
	$80,000-99,999	10.5%	10.7%	12.1%	9.6%	10.7%	
	More than $100,000'	14.7%	12.0%	11.8%	15.1%	13.4%	
Household members mean (SD)= 2.8 (1.4)	**1**	17.9%	17.3%	17.6%	20.0%	18.2%	0.302
	2	30.4%	32.2%	28.3%	28.5%	29.9%	
	3	24.0%	23.0%	21.5%	20.5%	22.3%	
	4	17.2%	16.5%	18.9%	18.6%	17.8%	
	5	6.7%	7.7%	9.1%	8.6%	8.0%	
	6	2.4%	2.4%	3.3%	1.9%	2.5%	
	7	0.4%	0.5%	0.4%	1.1%	0.6%	
	More than 7	1.0%	0.5%	1.0%	0.6%	0.8%	
Degree	**High School Diploma**	31.9%	34.1%	34.2%	34.7%	33.7%	0.165
	Bachelors degree	43.9%	43.0%	44.4%	46.1%	44.4%	
	Masters degree	13.9%	12.2%	13.1%	12.0%	12.8%	
	Doctorate degree	2.8%	1.8%	2.5%	2.2%	2.3%	
	Other	7.4%	8.9%	5.7%	4.9%	6.8%	
Living area	**Rural**	19.7%	21.5%	21.0%	22.7%	21.2%	0.678
	Urban	30.6%	32.2%	32.4%	31.7%	31.7%	
	Suburban	49.8%	46.3%	46.6%	45.6%	47.1%	
Ethnicity origin (or Race)	**White**	75.7%	78.0%	78.9%	76.9%	77.4%	0.187
	Hispanic or Latino	6.4%	5.8%	5.1%	5.7%	5.8%	
	Black or African American	6.2%	7.9%	7.8%	8.7%	7.6%	
	Native American or American Indian	0.9%	1.1%	0.6%	0.9%	0.9%	
	Asian / Pacific Islander	8.4%	6.1%	5.4%	6.6%	6.6%	
	Other (Please specify):	2.4%	1.1%	2.3%	1.1%	1.7%	
Employment situation	**Employed full time**	58.4%	58.0%	57.6%	61.2%	58.8%	0.682
	Employed part time	17.7%	16.4%	17.1%	14.8%	16.5%	
	Unemployed looking for work	7.3%	7.5%	6.7%	5.6%	6.8%	
	Unemployed not looking for work	5.8%	6.8%	6.0%	6.5%	6.3%	
	Retired	3.3%	2.7%	3.6%	3.2%	3.2%	
	Student	6.1%	5.7%	6.3%	6.8%	6.2%	
	Disabled	1.4%	2.9%	2.7%	1.9%	2.2%	

Figure 4.2. Results from information effect on comparison to US average per treatment

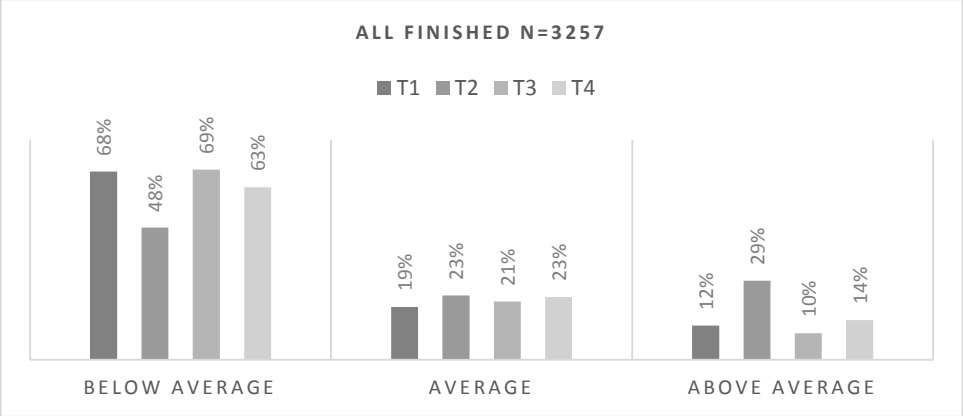


Table 4.3. Throwing above or below the average American, ANOVA test

Mean (SD) [likert scale 1-7]	***T1 Volume***	***T2 Money***	***T3 Meals***	***T4 Enviro.***	***All sample***	***Games-Howell post hoc test p-value***			
N	*808*	*823*	*837*	*789*	*3257*		***T1***	***T2***	***T3***
Throwing above or below the average American	**2.8** (1.4)	**3.5** (1.6)	**2.8** (1.3)	**3.0** (1.4)	**3.1** (1.4)	***T2***	0.000		
						T3	0.811	0.000	
						T4	0.039	0.000	0.002

Comparing our findings to previous publications, we found a greater percentage of participants in all treatments considering wasting the same or greater than the average American. Neff et al., (2015) –with the same question- obtained a 73% of their sample below the average, 24% reporting to waste the same and only a 3% answered to waste more than the average. There are two differences to take into account in this comparison. We had 7-point Likert scale instead of 3-point; it is possible that the number of scale items have an influence (Kormos and Gifford, 2014). Secondly, our participants read information about food waste in the US before answering. Indeed, we found a treatment effect on average score. Comparing to Qi and Roe, (2016), the differences are greater as they found that 86.5% disagree on wasting more than similarly size households

4.5.2. Self-reporting of food waste

4.5.2.1. Food in general

Participants in the volume treatment reported throwing away 5.61 pounds (2,546 grams) per household per week. Those who were assigned to the money treatment reported to throw away $15.37 equivalent of food in general wasted per household per week- which is equivalent (according the conversion factors explained in the method section) to 5,453 grams. Participants in the meal treatment estimated throwing away 8.78 meals equivalences per household, 3,164

grams equivalent. Finally, participants in the environmental treatment group estimated the carbon footprint generated due to the food thrown away. On average, they reported to throw away 19.83 kg CO^2 eq. of food in general that they throw away a week per household – which equals to 4,807 grams equivalent (see Table 4.4).

Comparing all treatment indicators in volume treatment equivalent (grams) per household, we observed that average food waste in the money framing treatment is greater than the others means. Next was the environment framing average food waste, followed by the meal framing treatment and, finally, the volume framing treatment that showed lower mean scores for all questions. These differences were tested using the ANOVA test, which verified a significant effect of treatment on self-reported food waste $F(3, 3253) = 88.41$, $p < 0.001$, $\omega = 0.27$. All post hoc comparisons using the Games-Howell test were significant ($p < 0.05$) (see Table 4.5).

Table 4.4. Household food waste per treatment in Food in general

Mean (SD** Per household**)		***T1 Volume*** [pounds]	***T2 Money*** [$]	***T3 Meal*** [nº meals]	***T4 Enviro.*** [kg CO^2 eq.]
Food in general (all types of food)	*Mean (SD)*	**5.61** (6.28)	**15.38** (14.49)	**8.78** (10.34)	**19.83** (18.52)
	Max-min	0.00-53.30	0.00-90.00	0.00-84.00	0.00-127.50

Table 4.5. Volume equivalent (in grams) and ANOVA post-hoc test in Food in general

Mean (SD) [grams] per household	***T1 Volume***	***T2 Money***	***T3 Meal***	***T4 Enviro.***	***Games-Howell post hoc test p-value***			
						T1	***T2***	***T3***
Food in general (all types of food)	**2,546** (2,849)	**5,453** (5,137)	**3,164** (3,728)	**4,807** (4,488)	***T2***	0.000		
					T3	0.001	0.000	
					T4	0.000	0.036	0.000

4.5.2.2. Sum food categories

In addition, we asked participants about some specific food categories. Summing these categories we obtained a *Sum Food Categories* indicator for each treatment. Overall, these new indicators are substantially greater than the reported food waste in the single indicator *Food in general* food waste.

When adding up separate categories, participants in the volume treatment reported throwing away 8.71 pounds (3,953 g) of food per household per week composed of: 1.29 pounds (585 g) of milk and dairy products, 2.20 pounds (996 g) of fruits and vegetables, 1.60 pounds (727 g) of meat and fish, 1.52 pounds (691 g) of bread and other bakery products, and 2.10 pounds (954 g) of processed or cooked food.

Participants who were assigned to the money treatment reported to throw away the equivalent to $22.67 equivalent per household per week if we sum all the specific food categories -8.037g converting it into volume equivalent. This amount is distributed in: $3.26 due to milk and dairy products, $5.67 due to fruits and vegetables, $4.41 due to meat and fish, $4.01 due to bread and other bakery products, and $5.32 due to processed or cooked food.

Participants in the meal treatment increased their estimated food waste up to 18.44 meals – 6,646 g in volume equivalent. This includes 2.89 meals of milk and dairy products, 4.19 meals of fruits and vegetables, 3.16 meals of meat and fish, 3.86 meals of bread and other bakery products, and 4.34 meals of processed or cooked food.

Finally, participants in the environmental estimated the carbon footprint generated due to the food thrown away 39.75 kg CO^2 eq. if we consider all specific food categories – equivalent to 9,634 g in volume equivalent). This includes 6.48 kg CO^2 eq. due to milk and dairy products thrown away, 7.71 kg CO^2 eq. due to fruits and vegetables, 8.12 kg CO^2 eq. due to meat and fish, 7.91 kg CO^2 eq. due to bread and bakery products and 9.54 kg CO2 eq.

Comparing all treatment indicators in volume treatment equivalent (grams) per household, overall the environment treatment average food waste is greater than the money, meal and finally, the volume reported food waste. All variables follow this order except for the fruit and vegetables in which money treatment average food waste is greater than environment one. The differences are statistically significant. The ANOVA test verified the significant effect of framing of the framing treatment on self-reported food waste on the indicator Sum of food categories $F(3, 3253) = 39.15$, $p < 0.001$, $\omega = 0.18$; on milk and dairy products $F(3, 3253) = 27.46$, $p < 0.001$, $\omega = 0.15$; on fruit and vegetables $F(3, 3253) = 28.80$, $p < 0.001$, $\omega = 0.16$; on meat and fish $F(3, 3253) = 35.81$, $p < 0.001$, $\omega = 0.18$; on bread and other bakery products $F(3, 3253) = 35.93$, $p < 0.001$, $\omega = 0.18$; on processed or cooked food $F(3, 3253) = 34.57$, $p < 0.001$, $\omega = 0.17$.

Moreover, we implemented post hoc comparisons using the Games-Howell test to compare all treatments with each other for every indicator. Table 4.7 summarizes every pair of comparisons indicating the p-value of the test. All planned contrasts were significant ($p < 0.05$), except for pairwise differences between money treatment (T2) and meal treatment (T3), in the Sum Food categories (P=0.055), in milk and dairy products (p=0.621), bread and other bakery products (p=0.970), and processed or cooked food (p=0.057); and pairwise differences between money treatment (T2) and environment treatment (T4) in fruits and vegetables (p=0.715)

Table 4.6. Household food waste per treatment per food categories

		T1 Volume *[pounds]*	***T2 Money*** *[$]*	***T3 Meal*** *[nº meals]*	***T4 Enviro.*** *[kg CO^2 eq.]*
Σ Food categories	*Mean (SD)*	**8.71** (14.71)	**22.67** (30.06)	**18.44** (32.47)	**39.75** (55.56)
	Max-min	0.00-218.90	0.00-321.60	0.00-273.00	0.00-488.70
Milk and dairy products	*Mean (SD)*	**1.29** (3.15)	**3.26** (5.80)	**2.89** (6.64)	**6.48** (11.01)
	Max-min	0.00-41.50	0.00-66.70	0.00-66.80	0.00-82.50
Fruits and vegetables	*Mean (SD)*	**2.20** (3.77)	**5.67** (7.04)	**4.19** (6.84)	**7.71** (11.51)
	Max-min	0.00-38.60	0.00-52.40	0.00-52.00	0.00-117.00
Meat and fish	*Mean (SD)*	**1.60** (3.35)	**4.41** (7.83)	**3.16** (7.05)	**8.12** (12.54)
	Max-min	0.00-45.00	0.00-75.00	0-70.00	0-102.20
Bread and other bakery products	*Mean (SD)*	**1.52** (2.96)	**4.01** (6.64)	**3.86** (7.05)	**7.91** (12.30)
	Max-min	0.00-47.30	0.00-75.00	0.00-58.80	0.00-111.30
Processed or cooked food	*Mean (SD)*	**2.10** (3.59)	**5.32** (7.89)	**4.34** (7.92)	**9.54** (14.14)
	Max-min	0.00-46.50	0.00-66.90	0.00-66.10	0.00-114.80

Table 4.7. Volume equivalent (in grams) and ANOVA post-hoc test per food categories

Mean (SD) [grams] household	***T1 Volume***	***T2 Money***	***T3 Meal***	***T4 Enviro.***	***Games-Howell post hoc test p-value***		
						T1	***T2***	***T3***
Σ Food categories	**3,953** (6,670)	**8,037** (10,659)	**6,646** (11,701)	**9,634** (13,463)	***T2***	0.000		
					T3	0.000	**0.055**	
					T4	0.000	0.042	0.000
Milk and dairy products	**585** (1,431)	**1,157** (2,055)	**1,043** (2,395)	**1,569** (2,669)	***T2***	0.000		
					T3	0.000	**0.723**	
					T4	0.000	0.003	0.000
Fruits and vegetables	**996** (1,710)	**2,009** (2,495)	**1,511** (2,466)	**1,869** (2,788)	***T2***	0.000		
					T3	0.000	0.000	
					T4	0.000	**0.715**	0.031
Meat and fish	**727** (1,520)	**1,564** (2,776)	**1,138** (2,541)	**1,967** (3,039)	***T2***	0.000		
					T3	0.000	0.006	
					T4	0.000	0.029	0.000
Bread and other bakery products	**691** (1,342)	**1,420** (2,354)	**1,389** (2,542)	**1,917** (2,980)	***T2***	0.000		
					T3	0.000	**0.994**	
					T4	0.000	0.001	0.001
Processed or cooked food	**954** (1,627)	**1,886** (2,799)	**1,565** (2,854)	**2,311** (3,427)	***T2***	0.000		
					T3	0.000	**0.094**	
					T4	0.000	0.034	0.000

4.5.2.3. Relevance of each food category

The Sum of food categories (Σ Food categories) indicator is composed of five categories of food. We estimated, for each respondent (regardless the amount of food waste), the share of each food category over the respondent's household total Sum of Food categories food waste amount. Table 4.8. shows the average importance of each food category within treatment. Overall, two categories accounted for half of respondents' household food waste: fruits and vegetables and,

processed or cooked food. Milk and dairy food was the category that counted the least to the Sum of food waste in all treatments. Differences among treatments are visible. There is an eight percentage point difference for the share of fruits and vegetables category between money treatment (30%) and environment treatment (22%) groups. In the environment treatment group the processed or cooked foods has the highest rate (24%). The rate of fruits and vegetables category has the highest percentage in all treatment groups except for environment group, where it is the second highest with a 22% share.

These differences were tested statistically. We found a significant effect for the shares of all food categories across treatment groups: milk and dairy share F (3, 3172) =3.72, p= 0.011, ω=0.05; on fruit and vegetables share F (3, 3172) =24.04, p= 0.000, ω=0.15; on meat and fish share F (3, 3172) =12.57, p= 0.000, ω=0.10; on bread and other bakery products share F (3, 3172) =7.81, p= 0.000, ω=0.08; and, on processed food share F (3, 3172) =3.14, p= 0.024, ω=0.04. Table 4.8 shows average share for treatment and post hoc analysis using the Games-Howell test.

Table 4.8 Average of food categories shares of Sum of food categories participant's food waste

Mean (SD) [%] household	***T1 Volume***	***T2 Money***	***T3 Meal***	***T4 Enviro.***	***All sample***	***Games-Howell post hoc test***			***p-value***
							T1	***T2***	***T3***
	789	*802*	*804*	*781*	*3176*				
Milk and dairy products	**13.2** (13.5)	**13.8** (13.0)	**13.8** (13.6)	**15.3** (12.7)	**14.0** (13.2)	***T2***	0.794		
						T3	0.830	1.000	
						T4	0.007	0.089	0.088
Fruits and vegetables	**27.5** (19.3)	**30.0** (21.2)	**27.0** (19.8)	**22.0** (15.9)	**26.6** (19.4)	***T2***	0.079		
						T3	0.954	0.022	
						T4	0.000	0.000	0.000
Meat and fish	**15.9** (14.7)	**16.2** (15.5)	**14.6** (14.2)	**19.0** (13.6)	**16.4** (14.6)	***T2***	0.976		
						T3	0.245	0.113	
						T4	0.000	0.001	0.000
Bread and other bakery products	**18.0** (14.5)	**17.4** (13.7)	**20.4** (15.6)	**19.6** (11.6)	**18.8** (14.0)	***T2***	0.807		
						T3	0.010	0.000	
						T4	0.084	0.003	0.664
Processed or cooked food	**25.3** (18.4)	**22.6** (18.9)	**24.2** (18.3)	**24.1** (15.4)	**24.1** (17.8)	***T2***	0.019		
						T3	0.648	0.287	
						T4	0.521	0.280	0.999

NB: N finished=3257. There are 81 individuals who reported zero waste (T1=19, T2=21, T3=33, T4=8)

4.5.3. Accuracy of the self reports assessment

We included both food in general (the total food waste) and separate food categories for food waste estimation. The reported results show that consumers tend to underestimate the amount wasted food when asked in general terms. The average numbers for food waste in food in general were markedly lower compared to the sum of food waste in all food categories, despite the warning. Table 4.9 compares weekly per capita food waste in each treatment for the food in general question and the Sum food categories indicator. Underestimation due to a single indicator question has been previously discussed in food consumption studies (Conforti et al., 2017). Again, there was treatments differences. In the environment treatment, the Sum o food categories (13.39

kg CO^2 eq.) doubles the Food in general average score (6.8 kg CO^2 eq.). The same is observed in the meals treatment, 3 meals versus 6 meals. In the volume treatment, the underestimation is not so big, there is 500 grams of difference among the two indicators. Finally, in money participants seemed reported more accurate estimations comparing Food in general $5.53 to the Sum food categories $8.12.

While our sample is not nationally representative, we consider that it is meaningful to compare our findings to previous estimates on the US. By doing so, the differences among treatments that have been explained previously are highlighted. Table 4.9, shows average food waste per capita reported in our survey in all four treatments, compared to previous published studies. The volume treatment group reported substantially lower food waste, 919.5 g or 1,436.3 g (Food in general and Sum food categories respectively) per person per week, than the food waste in other studies. Our average score is closer to Thyberg et al., (2015) estimations of 1,953 g per capita per day of food waste disposed and managed by the waste treatment systems[18]. Buzby et al., (2014), Buzby and Hyman, (2012) and Conrad et al., (2018) noted substantially higher quantity of food waste, 2,522.8 g, 2,374.4 g and 2,950.5 grams per person per day accordingly[19].

On the other hand, the comparison of average scores in the other three treatments to literature shows that average scores in money, meals and environment treatment groups are not so far from literature than the volume one. The money treatment group average score is close to the mean reported in Buzby and Hyman, (2012) $7.49 and in Buzby et al.,(2014) $7.14. The Food in general $5.53 is lower, but the Sum food indicator average score $8.12 is slightly greater. Regarding to meals, there is no previous study that analyzes food waste in number of meals. However, as we used number of meals as a proxy of calories - 759-800 kcal (Buzby et al., 2014; Conrad et al., 2018; Spiker et al., 2017) would be equivalent to 7 meals wasted per week. Our survey average meals is below in food in general estimation – 3meals. Yet, it is one meal lower in the Sum food categories indicator which is 6 meals a week per person. Finally, the average score obtained in the environment treatment was lower to 9.8 kg CO^2 eq. from Heller and Keoleian, (2014) in the food in general score 6.80 kg CO^2 eq. from. However, the Sum of food categories is greater kg CO^2 eq.

[18]They estimated the aggregate disposal rate for food waste from 1995-2013 by means of a meta-analysis of US waste characterizations.

[19] It must be noted that all three used USDA Loss-Adjusted Food Availability data series (LAFA), which contains data of the portion of food that is not consumed from 200 food items at different stages. Consumer stage represents household and food services together. There is not enough information from the studies to distinguish in-home and out-home food waste.

Table 4.9 Food in general and Sum food categories average score compared to literature

	***Mean** 95% CI per capita per week*	*grams equivalences per capita per week*	*Previous literature per capita per week*
Volume treatment			***2,522.8 g** (Buzby et al., 2014)* [a]
Food in general	**2.03** (1.96 -2.09) pounds	**919.5** (890.3 - 948.7) g	*2,374.4 g (Buzby and Hyman, 2012)* [a]
Σ Food categories	**3.17** (3.01-3.32) pounds	**1,436.3** (1,365.1 - 1,507.6) g	2,950.5 g *(Conrad et al., 2018)* [a]
			1,953 g *(Thyberg et al., 2015)* [b]
Money treatment			
Food in general	**$5.53** (5.39 -5.67)	**1,962.0** (1,912.1 - 2,012.0) g*	***$7.14** (Buzby et al., 2014)* [a]
Σ Food categories	**$8.12** (7.81 -8.43)	**2,877.8** (2,768.4 - 2,987.2) g*	$7.49 *(Buzby and Hyman, 2012)* [a]
Meal treatment			
Food in general	**2.96** (2.87-3.06) meals	**1,068.5** (1,032.7 - 1,104.2) g*	**789 kcal/day** *(Buzby et al., 2014)* [a]
Σ Food categories	**5.93** (5.64-6.22) meals	**2,136.1** (2,032.3 - 2,239.9) g*	800 kcal/day *(Conrad et al., 2018)* [a]
			759 kcal/day *(Spiker et al., 2017)*
Environment treatment			
Food in general	**6.80** (6.64-6.97) kg CO^2 eq.	**1,648.8** (1,609.6 - 1,688.1) g*	***9.8** **kg CO^2 eq.***
Σ Food categories	**13.39** (12.86 -13.92) kg CO^2 eq.	**3,244.4** (3,116.7 - 3,372.2) g*	*(Heller and Keoleian, 2014)*

* grams equivalences using conversions from the base scenario; a)Includes household and food services b) disposal rate of food waste

4.5.4. Robustness checks

We acknowledge that the differences found among treatments in Table 4.7 rely on the conversion factor applied to each treatment. However, we used Buzby et al., (2014), which is an update of Buzby and Hyman, (2012) the using the same methods for US consumer food waste. The latter is one of the top 10 most cited publications on food waste (Xue et al., 2017) and it is widely used as a reference to estimate food waste impacts. Further research would be optimal to validate the accuracy of these conversion. However, we carried out a robustness check to evaluate the validity the effect of treatment on self-reported food waste.

4.5.4.1. Alternative scenarios

We applied alternative conversion factors to money, meal, and environment treatments for obtaining the Sum of food categories indicator. We established four increasing scenarios (20%, 30%, 40%, 50%) and four decreasing (20%, 30%, 40%, 50%) conversion factors. Table 4.10 shows the base scenario conversion and the new options.

The t-test analyses carried out between volume treatment and money, meal and environment treatment for all alternatives scenarios (Figure 4.3) were all significant ($p<0.05$) except for the 50% decrease scenario (LLLLS) in money treatment ($p=0.826$); the 40% decrease scenario of meal treatment (LLLS) ($p=0.918$) and 30% decrease scenario (LLS) that was significant at $p<0.10$ ($p=0.057$). Therefore, we confirm the statistical significant differences found among treatments because even with changes in the conversion factors the relationships are still significantly different.

4.5.4.2. Plausibility of scenarios

As a conversion factor from money to pounds we used the aggregated price in $ per total of food wasted in pounds. This entails inaccuracies because the conversion factor would change depending on the type of food wasted (meat waste increase the total economic impact of the food wasted although it decreased the volume in weight). Moreover, the prices used in Buzby's report (Buzby et al., 2014) were from retail prices for 2010 using Nielsen Homescan data.

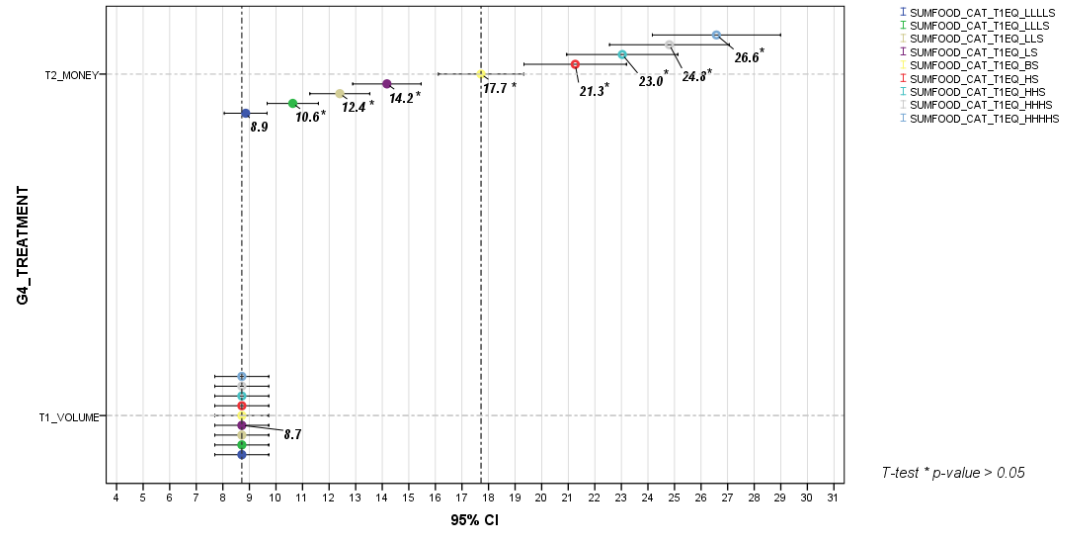
In the case of meals conversion, we consider decreasing scenarios are not very plausible. Our base scenario is considering Buzby et al.'s 789 calories (Buzby et al., 2014) as a one meal, that corresponds to 360 grams. The amountof calories would depend, again, on the composition of the food wasted. However, a recent publication estimated US consumer food waste - using similar methods and databases as Buzby – that the estimated 2,950 grams of food waste per capita per week from 2007-2014 corresponded to 800 calories per day.

Fewer publications can be found estimating the environmental impact of consumers' food waste. Thus, it is difficult to discriminate the validity of the conversion. We rely on the mentioned publication (Heller and Keoleian, 2014).

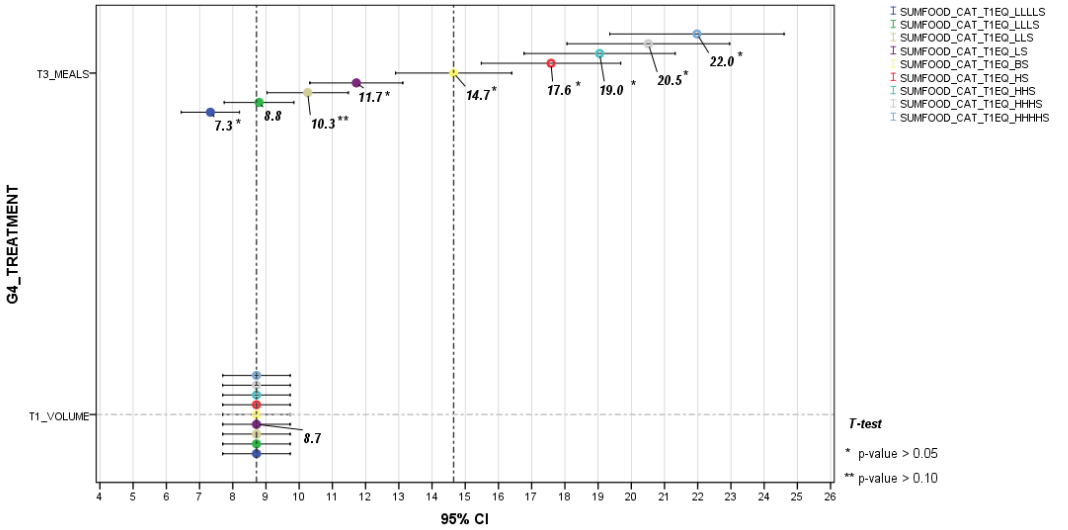
Table 4.10 Conversion scenarios from money, meal and environment treatment to volume one

	Scenarios		*Decrease 50%* *(LLLLS)*	*Decrease 40%* *(LLLS)*	*Decrease 30%* *(LLS)*	*Decrease 20%* *(LS)*	**BASE** ***(BS)***	*Increase 20%* *(HS)*	*Increase 30%* *(HHS)*	*Increase 40%* *(HHHS)*	*Increase 50%* *(HHHHS)*
T1							**8.71 (14.71)**				
T2-->T1	*Conversion factor*	*pounds* / *$*	145 / 371	174 / 371	203 / 371	232 / 371	**290 / 371**	348 / 371	377 / 371	406 / 371	435 / 371
	Σ Food categories (pounds)	Mean (SD)	**8.86** (11.75)	**10.63** (14.10)	**12.40** (16.45)	**14.17** (18.80)	**17.72** (23.50)	**21.26** (28.20)	**23.03** (30.55)	**24.81** (32.90)	**26.58** (35.25)
T3-->T1	*Conversion factor*	*pounds* / *meals*	145 / 365	174 / 365	203 / 365	232 / 365	**290 / 365**	348 / 365	377 / 365	406 / 365	435 / 365
	Σ Food categories (pounds)	Mean (SD)	**7.33** (12.90)	**8.79** (15.48)	**10.26** (18.06)	**11.72** (20.64)	**14.65** (25.80)	**17.58** (30.96)	**19.05** (33.53)	**20.51** (36.11)	**21.98** (38.69)
T4-->T1	*Conversion factor*	*pounds* / *kg CO2*	136.5 / 511	163.8 / 511	191.1 / 511	218.4 / 511	**273 / 511**	327.6 / 511	354.9 / 511	382.2 / 511	409.5 / 511
	Σ Food categories (pounds)	Mean (SD)	**10.62** (14.84)	**12.74** (17.81)	**14.87** (20.78)	**16.99** (23.74)	**21.24** (29.68)	**25.49** (35.62)	**27.61** (38.59)	**29.73** (41.55)	**31.86** (44.52)

a) ***Volume vs money treatment***



b) Volume vs meal treatment



c) ***Volume vs environment treatment***

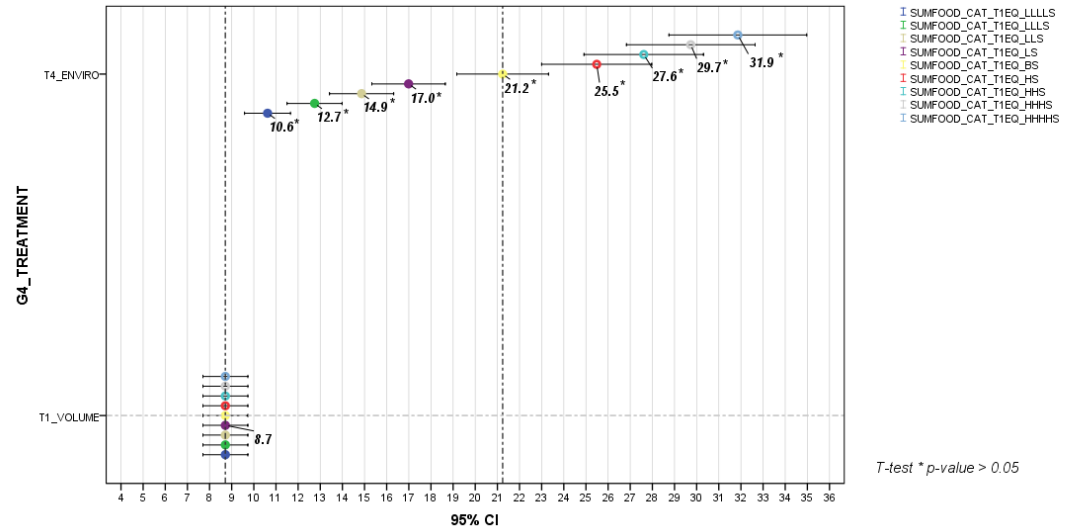


Figure 4.3 Test of t-statistic for every scenario to volume treatment food waste of Sum of categories variable

4.2. Conclusions

To our knowledge, this is the first article providing a quantitative measure of consumer food waste using a self-reporting survey. From all direct measurement by means of self-reporting survey, this is the only known study that uses continuous scale survey to elicit consumers' real food waste using different framing language. Moreover, we opened the scope to future researchers to use alternative dimensions to measure household food waste such as in monetary value, in meal equivalences or in environmental impact.

As the survey experiment was implemented in the US, the questionnaire treatments were adapted to US available information. Although the US is one of regions with more published data on food waste, our results obtained one of the biggest samples (3,257 respondents) that quantified in-home food waste. It should be noted that consumer food waste is usually considered out-of-home and in-home all together. In-home focused studies are necessary since it is the more invisible behaviour.

We found a significant effect of framing and information on consumers' perception of their food waste in home. The results show differences among treatments on the quantity of food waste reported, the distribution of it among food categories and the influence of treatment together with information on consumers' food waste comparison to an average consumer. Overall, we found that the environment self-reporting average food waste was higher than the money in dollars, the number of meals and the volume in pounds. Money treatment was substantially different in the information question. And, the environment treatment presented differences while attending to the importance of food categories over the total food waste.

It should be noted that we rely on the conversion factors from the literature and the results would change if we use alternative conversion rates. However, we employed robust checks to support our findings and the rate's test of variance – which is not scale depending – was also significant. It is important to note, that the effect of the differences was less powerful when using the shares' test of variance of means. We highly encourage further research to contrast and validate the conversion factors from weight to monetary impact, meals equivalent and environmental impact. At the same time, a future survey experiment could be employed to test all four treatments in the same sample to evaluate differences within individuals once they are exposed to different dimensions of food waste.

It seems that consumers in the volume treatment group have underestimated their household food waste. However, we have to rely on self-reporting nature of this article and we need extra information to validate the numbers. New experimental studies should consider contrasting the food waste generated in weight (pounds/kg) by means of different direct measurements like

kitchen diaries, recall self-reporting surveys (as we employed) and curbside waste characterization.

We acknowledge that the environment treatment framing was an unconventional way to ask consumers about their waste. But, surprisingly we obtained coherent results compared to the other framings. Moreover, it can be considered that the change in the importance of the different food categories over the total food waste validate the coherence. Respondents of environment framing considered to throw away more meat and fish, and processed or cooked food and less fruits and vegetables than the other treatments. This might suggest that participants were thinking on the environmental consequences of the food thrown away.

Based on this, we suggest policy makers and campaigners to refer to the environmental impact when communicating and campaigning towards a reduction of meat and fish and processed or cooked products. Participants in money treatment tend to think they waste more. Therefore, recalling to the monetary impact of food waste would influence on consumers significantly.

From our findings, we also have some recommendation to future consumer food waste studies. We tested the option of asking household food waste in a continuous scale. We used a slider delimited from 0 to the double of US consumer food waste. The results obtained are promising to avoid zero-waste answers, which is commonly found in consumer's surveys. We only had 2.5% of individuals reporting to throw nothing. We recommend using the slider as an alternative to categorical qualitative scales to measure food waste in other regions. Cause-predictor models would significantly improve and provide more accurate recommendation to address the reduction of generated volumes. Moreover, in light of the underestimation of food waste using the Food in general single indicator, we recommend avoiding a single indicator question and using more than one category to measure consumers' food waste.

Appendix

Figure A4.1. Caption of the online survey self-reporting question example of volume treatment

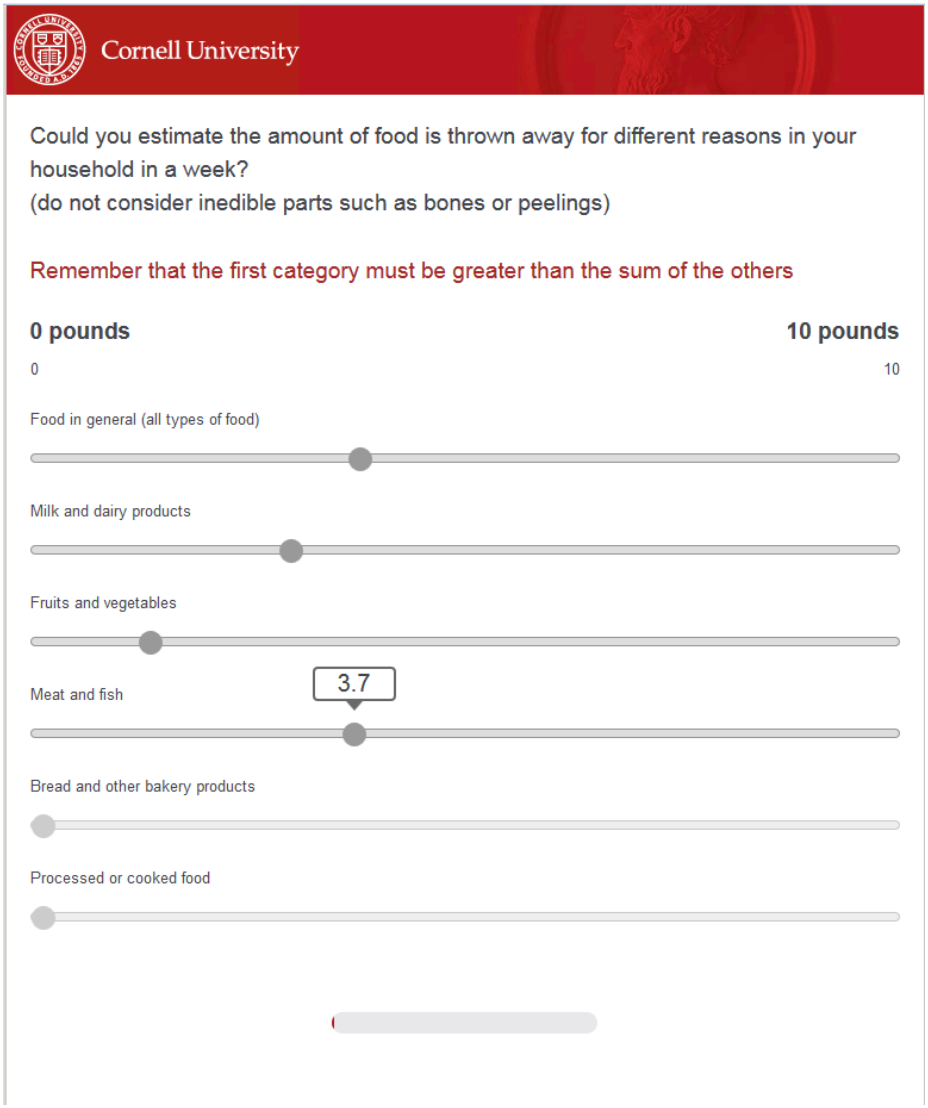


Table A4.1. Sample characteristics compared to US average

	Sample	*3257*		U.S. %	Source
Gender	**Female**	**57.0%**		51.40%	DP05: ACS DEMOGRAPHIC AND HOUSING ESTIMATES 2012-2016 American Community Survey 5-Year Estimates
	Male	**43.0%**		48.60%	*Percentage is based on the population over 18-year-old18 years and over
Age	**18-24**	**13.2%**		12.8%	DP05: ACS DEMOGRAPHIC AND HOUSING ESTIMATES 2012-2016 American Community Survey 5-Year Estimates
	25-34	**40.9%**		17.7%	*Percentage is based on the population over 18-year-old18 years and over
	35-44	**22.8%**		16.6%	
	45-54	**12.8%**		17.7%	
	55-64	**7.7%**		16.4%	
	65 or more	**2.5%**		18.9%	
Income	**Less than $10,000**	**4.8%**		6%	Source: U.S. Census Bureau, Current Population Survey, 2017 Annual Social and Economic Supplement.
	$10,000-$19,999	**8.6%**		9%	
	$20,000-39,999	**23.6%**		19%	
	'$40,000-59,999	**21.6%**		16%	
	$60,000-79,999	**17.2%**		12%	
	$80,000-99,999	**10.7%**		9%	
	More than $100,000'	**13.4%**		28%	
Household members				Average household size 2.64 people	DP02: SELECTED SOCIAL CHARACTERISTICS IN THE UNITED STATES 2012-2016 American Community Survey 5-Year Estimates
Living area	**Rural**	**21.2%**		21%	Source: U.S. Census Bureau, 2010 Census.
	Urban	**31.7%**		Not suburban found	
	Suburban	**47.1%**	Urban	79%	Source: U.S. Census Bureau, 2010 Census.
Ethnicity origin (or Race)	**White**	**77.4%**	White alone	62.00%	DP05: ACS DEMOGRAPHIC AND HOUSING ESTIMATES 2012-2016 American Community Survey 5-Year Estimates
	Hispanic or Latino	**5.8%**		17.30%	
	Black or African American	**7.6%**	Black or African American alone	12.30%	
	Native American or American Indian	**0.9%**	American Indian and Alaska Native alone	0.70%	
	Asian / Pacific Islander	**6.6%**	Asian alone + Native Hawaiian and Other Pacific Islander alone	5.40%	
	Other (Please specify):	**1.7%**			
Employment situation	**Employed full time**	**58.8%**	Civilian In laborforce Employed	58.4%	DP03: SELECTED ECONOMIC CHARACTERISTICS 2012-2016 American Community Survey 5-Year Estimates *Population 16 years and over
	Disabled	**2.2%**			

References

Abeliotis, K., Lasaridi, K., Chroni, C., 2014. Attitudes and behaviour of Greek households regarding food waste prevention. Waste Manag. Res. 32, 237–40. doi:10.1177/0734242X14521681

Bellemare, M.F., Çakir, M., Peterson, H.H., Novak, L., Rudi, J., 2017. On the Measurement of Food Waste. Am. J. Agric. Econ. 99, 1148–1158. doi:10.1093/ajae/aax034

Beretta, C., Stucki, M., Hellweg, S., 2017. Environmental Impacts and Hotspots of Food Losses: Value Chain Analysis of Swiss Food Consumption. Environ. Sci. Technol. 51, 11165–11173. doi:10.1021/acs.est.6b06179

Berinsky, A.J., Huber, G.A., Lenz, G.S., 2012. Evaluating online labor markets for experimental research: Amazon.com's mechanical turk. Polit. Anal. 20, 351–368. doi:10.1093/pan/mpr057

Biodiversity International, 2014. Bioversity International's 10-year strategy 2014-2024. doi:ISBN: 978-92-9043-992-9

Buzby, J.C., Hyman, J., 2012. Total and per capita value of food loss in the United States. Food Policy 37, 561–570. doi:10.1016/j.foodpol.2012.06.002

Buzby, J.C., Wells, H.F., Hyman, J., 2014. The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States. Econ. Inf. Bull. 39.

Chaboud, G., Daviron, B., 2017. Food losses and waste: Navigating the inconsistencies. Glob. Food Sec. 12, 1–7. doi:10.1016/j.gfs.2016.11.004

Clifford, S., Jewell, R.M., Waggoner, P.D., 2015. Are samples drawn from Mechanical Turk valid for research on political ideology? Res. Polit. 2, 205316801562207. doi:10.1177/2053168015622072

Conforti, P., Grünberger, K., Troubat, N., 2017. The impact of survey characteristics on the measurement of food consumption. Food Policy 72, 43–52. doi:10.1016/J.FOODPOL.2017.08.011

Conrad, Z., Niles, M.T., Neher, D.A., Roy, E.D., Tichenor, N.E., Jahns, L., 2018. Relationship between food waste, diet quality, and environmental sustainability. PLoS One 13, e0195405. doi:10.1371/journal.pone.0195405

Cristóbal, J., Castellani, V., Manfredi, S., Sala, S., 2017. Prioritizing and optimizing sustainable measures for food waste prevention and management. Waste Manag. 72, 3–16. doi:10.1016/j.wasman.2017.11.007

Deryugina, T., Shurchkov, O., 2016. The effect of information provision on public consensus about climate change. PLoS One 11. doi:10.1371/journal.pone.0151469

Dou, Z., Ferguson, J.D., Galligan, D.T., Kelly, A.M., Finn, S.M., Giegengack, R., 2016. Assessing U.S. food wastage and opportunities for reduction. Glob. Food Sec. 8, 19–26. doi:10.1016/j.gfs.2016.02.001

FAO, 2013a. Climate-Smart Agriculture Sourcebook, Sourcebook on Climate-Smart Agriculture, Forestry and Fisheries.

FAO, 2013b. Food wastage footprint. Impacts on natural resources. Summary Report.

FAO, IFAD, WFP., 2015. The State of Food Insecurity in the World: Meeting the 2015 international hunger targets: taking stock of uneven progress., FAO, IFAD and WFP. doi:I4646E/1/05.15

Friedman, J., Beegle, K., De Weerdt, J., Gibson, J., 2017. Decomposing response error in food consumption measurement: Implications for survey design from a randomized survey experiment in Tanzania. Food Policy 72, 94–111. doi:10.1016/J.FOODPOL.2017.08.016

FUSIONS, 2014. Standard approach on quantitative techniques to be used to estimate food waste levels.

FUSIONS, 2015. FUSIONS food waste data set for EU-28. FUSIONS EU Proj.

FUSIONS, 2016. Food waste quantification manual to monitor food waste amounts and progression.

Garrone, P., Melacini, M., Perego, A., 2014. Opening the black box of food waste reduction. Food Policy 46, 129–139. doi:10.1016/j.foodpol.2014.03.014

Gustavsson, J., Cedeberg, C., Sonesson, U., Otterdijk, R. van, Meybeck, A., 2011. Global food losses and food waste - Extent, causes and prevention. Rome.

Hall, K.D., Guo, J., Dore, M., Chow, C.C., 2009. The progressive increase of food waste in America and its environmental impact. PLoS One 4, e7940. doi:10.1371/journal.pone.0007940

Heller, M.C., Keoleian, G.A., 2014. Greenhouse Gas Emission Estimates of U.S. Dietary Choices and Food Loss. J. Ind. Ecol. 00, 1–11. doi:10.1111/jiec.12174

Herpen, E. van, Lans, I. van der, Vries, M.N., Holthuysen, N., Kremer, S., Stijnen, D., 2016. Consumption life cycle contributions Assessment of practical methodologies for in-home food waste measurement.

HLPE, 2014. Food losses and waste in the context of sustainable food systems. A Rep. by High Lev. Panel Expert. Food Secur. Nutr. Comm. World Food Secur. Rome 2014.

Holleman, B., Kamoen, N., Krouwel, A., Van De Pol, J., De Vreese, C., 2016. Positive vs. Negative: The impact of question polarity in voting advice applications. PLoS One 11. doi:10.1371/journal.pone.0164184

IBM Corp. Released, 2016. IBM SPSS Statistics for Windows, Version 24.0. 2016.

Intergovernmental Panel on Climate Change, 2014. Climate Change 2014 Mitigation of Climate Change, Cambridge University Press, Cambridge, UK and New York, NY. doi:10.1017/CBO9781107415416

Jörissen, J., Priefer, C., Bräutigam, K.-R.R., 2015. Food waste generation at household level: Results of a survey among employees of two European research centers in Italy and Germany. Sustain. 7, 2695–2715. doi:10.3390/su7032695

Just, D.R., Gabrielyan, G., 2016. Food and consumer behavior: why the details matter. Agric. Econ. (United Kingdom) 47, 73–83. doi:10.1111/agec.12302

Just, D.R., Wansink, B., 2014. One man's tall is another man's small: How the framing of portion size influences food choice. Heal. Econ. (United Kingdom) 23, 776–791. doi:10.1002/hec.2949

Katajajuuri, J.-M., Silvennoinen, K., Hartikainen, H., Heikkilä, L., Reinikainen, A., 2014. Food waste in the Finnish food chain. J. Clean. Prod. 73, 322–329. doi:10.1016/j.jclepro.2013.12.057

Kormos, C., Gifford, R., 2014. The validity of self-report measures of proenvironmental behavior: Ameta-analytic review. J. Environ. Psychol. 40, 359–371. doi:10.1016/j.jenvp.2014.09.003

Kummu, M., de Moel, H., Porkka, M., Siebert, S., Varis, O., Ward, P.J., 2012. Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use. Sci. Total Environ. 438, 477–489. doi:10.1016/j.scitotenv.2012.08.092

Langen, N., Goebel, C., Waskow, F., Göbel, C., Waskow, F., 2015. The effectiveness of advice and actions in reducing food waste. Proc. Inst. Civ. Eng. - Waste Resour. Manag. 168, 72–86. doi:10.1680/warm.13.00036

Mena, C., Adenso-Diaz, B., Yurt, O., 2011. The causes of food waste in the supplier-retailer interface: Evidences from the UK and Spain. Resour. Conserv. Recycl. 55, 648–658. doi:10.1016/j.resconrec.2010.09.006

Milfont, T.L., 2009. The effects of social desirability on self-reported environmental attitudes and ecological behaviour. Environmentalist 29, 263–269. doi:10.1007/s10669-008-9192-2

Mourad, M., 2016. Recycling, recovering and preventing "food waste": competing solutions for food systems sustainability in the United States and France. J. Clean. Prod. 126, 461–477. doi:10.1016/j.jclepro.2016.03.084

Nahman, a, de Lange, W., Oelofse, S., Godfrey, L., 2012. The costs of household food waste in South Africa. Waste Manag 32, 2147–53. doi:10.1016/j.wasman.2012.04.012

Neff, R. a., Spiker, M.L., Truant, P.L., 2015. Wasted Food: U.S. Consumers' Reported Awareness, Attitudes, and Behaviors. PLoS One 10, e0127881. doi:10.1371/journal.pone.0127881

Parfitt, J., Barthel, M., Macnaughton, S., 2010. Food waste within food supply chains: quantification and potential for change to 2050. Philos. Trans. R. Soc. Lond. B. Biol. Sci. 365, 3065–81. doi:10.1098/rstb.2010.0126

Parizeau, K., Massow, M. von, Martin, R., von Massow, M., Martin, R., 2015. Household-level dynamics of food waste production and related beliefs, attitudes, and behaviours in Guelph, Ontario. Waste Manag. 35, 207–217. doi:10.1016/j.wasman.2014.09.019

Principato, L., Secondi, L., Pratesi, C.A., 2015. Reducing food waste: an investigation on the behaviour of Italian youths. Br. Food J. 117, 731–748. doi:10.1108/BFJ-10-2013-0314

Qi, D., Roe, B.E., 2016. Household food waste: Multivariate regression and principal components analyses of awareness and attitudes among u.s. consumers. PLoS One 11, 1–19. doi:10.1371/journal.pone.0159250

Quested, T.E.E., Marsh, E., Stunell, D., Parry, A.D.D., 2013. Spaghetti soup: The complex world of food waste behaviours. Resour. Conserv. Recycl. 79, 43–51. doi:10.1016/j.resconrec.2013.04.011

ReFED, 2016. ReFED Rethink Food WAste Through Economics and Data [WWW Document].

Roodhuyzen, D.M.A., Luning, P.A., Fogliano, V., Steenbekkers, L.P.A., 2017a. Putting together the puzzle of consumer food waste: Towards an integral perspective. Trends Food Sci. Technol. 68, 37–50. doi:10.1016/j.tifs.2017.07.009

Roodhuyzen, D.M.A., Luning, P.A., Fogliano, V., Steenbekkers, L.P.A., 2017b. Putting together the puzzle of consumer food waste: Towards an integral perspective. Trends Food Sci. Technol. 68, 37–50. doi:10.1016/j.tifs.2017.07.009

Save The Food, 2016. Save The Food [WWW Document].

Secondi, L., Principato, L., Laureti, T., 2015. Household food waste behaviour in EU-27 countries: A multilevel analysis. Food Policy 56, 25–40. doi:10.1016/j.foodpol.2015.07.007

Setti, M., Falasconi, L., Segrè, A., Cusano, I., Vittuari, M., 2016. Italian consumers' income and food waste behavior. Br. Food J. Iss Br. Food J. Br. Food J. Br. Food J. 118, 1731–1746. doi:10.1108/02656710210415703

Spiker, M.L., Hiza, H.A.B., Siddiqi, S.M., Neff, R.A., 2017. Wasted Food, Wasted Nutrients: Nutrient Loss from Wasted Food in the United States and Comparison to Gaps in Dietary Intake. J. Acad. Nutr. Diet. 117, 1031–1040.e22. doi:10.1016/j.jand.2017.03.015

Stancu, V., Haugaard, P., Lähteenmäki, L., 2016. Determinants of consumer food waste behaviour: Two routes to food waste. Appetite 96, 7–17. doi:10.1016/j.appet.2015.08.025

Stefan, V., van Herpen, E., Tudoran, A.A., Lähteenmäki, L., L??hteenm??ki, L., 2013. Avoiding food waste by Romanian consumers: The importance of planning and shopping routines. Food Qual. Prefer. 28, 375–381. doi:10.1016/j.foodqual.2012.11.001

Stuart, T., 2009. Waste: Uncovering the Global Food Scandal. Penguin books, London.

Think Eat Save, 2016. Think Eat Save [WWW Document].

Thyberg, K.L., Tonjes, D.J., 2016. Drivers of food waste and their implications for sustainable policy development. Resour. Conserv. Recycl. 106, 110–123. doi:10.1016/j.resconrec.2015.11.016

Thyberg, K.L., Tonjes, D.J., Gurevitch, J., 2015. Quantification of Food Waste Disposal in the United States: A Meta-Analysis. Environ. Sci. Technol. 49, 13946–13953. doi:10.1021/acs.est.5b03880

Tucker, C. a., Farrelly, T., 2015. Household food waste: the implications of consumer choice in food from purchase to disposal. Local Environ. 21, 682–706. doi:10.1080/13549839.2015.1015972

United Nations, 2015. Transforming our world: the 2030 Agenda for Sustainable Development, General Assembley 70 session. doi:10.1007/s13398-014-0173-7.2

Visschers, V.H.M.M., Wickli, N., Siegrist, M., 2016. Sorting out food waste behaviour: A survey on the motivators and barriers of self-reported amounts of food waste in households. J. Environ. Psychol. 45, 66–78. doi:10.1016/j.jenvp.2015.11.007

Vogliano, C., Brown, K., 2016. The State of America's Wasted Food and Opportunities to Make a Difference. J. Acad. Nutr. Diet. 116, 1199–1207. doi:10.1016/j.jand.2016.01.022

West, P.C., Gerber, J.S., Engstrom, P.M., Mueller, N.D., Brauman, K.A., Carlson, K.M., Cassidy, E.S., Johnston, M., MacDonald, G.K., Ray, D.K., Siebert, S., 2014. Leverage points for improving global food security and the environment. Science (80-.). 345, 325–328. doi:10.1126/science.1246067

World Resources Institute, 2016. Food Loss and Waste Accounting and Reporting Standard 160.

Xue, L., Liu, G., Parfitt, J., Liu, X., Van Herpen, E., Stenmarck, Å., O'Connor, C., Östergren, K., Cheng, S., 2017. Missing Food, Missing Data? A Critical Review of Global Food Losses and Food Waste Data. Environ. Sci. Technol. 51, 6618–6633. doi:10.1021/acs.est.7b00401

CONCLUSIONS

On the debate on how to achieve more sustainable food systems, food waste emerged as one of the most tangible and visible outcomes of the current food systems. Addressing the food waste challenge is a societal and environmental responsibility to contribute to a more sustainable food system. Food waste occurrence is not new, but there has been an increasing interest in this topic by researchers and policy bodies during the last decade, which has contributed to improve the awareness and knowledge about the situation. However, the novelty of the topic and the multiplicity of conceptual frameworks and methodological approaches to address it have generated a scenario no exempted of uncertainties and inconsistencies.

Despite the discrepancies, it is generally agreed that the current situation is not sustainable and some changes need to take place. But firstly, there is a need to better understand the deeper root of the problem at multiple levels. The adoption of reductionist approaches will not contribute to solve the problem, neither partially, as they do not consider the complexity of the food systems - solving the problem at one stage of the food supply chain can generate a new problem downwards or upwards. Holistic approaches are needed to avoid falling into the trap of weak sustainability alternatives.

This thesis addresses the food waste debate from an innovative and holistic perspective. It contributes to the increasing body of literature by offering innovative approaches to study the food waste phenomenon with two critical focuses: a whole-supply approach and a multidimensional consumers' understanding. Moreover, all four chapters provide relevant first-hand information from the case studies, which has been one crucial shortcoming in previous food waste studies.

Food waste is an externality of the food system dynamics. Food systems are complex, and the behaviour of stakeholders at one specific stage of the food supply chain cannot be understood isolated from the behaviour of the other actors. Dividing the food system into smaller pieces – say stages- to simplify the analyses can be misleading. The approach used to analyse a problem will, ultimately, define the problem itself. In food waste research, most of the studies have focussed on specific stages of the food supply chain. The whole supply chain approach employed in **chapters 1 and 2** is meaningful to understand the structural nature of food waste generation and to find out potential solutions to prevent and reduce food waste addressing its structural nature (strong prevention solutions). The findings reinforce the necessity of holistic perspectives to tackle food waste.

The whole-supply approach in **chapter 1**, aimed at understanding the causes of food waste volumes, along with the heterogeneous sample of stakeholders belonging to the different stages of the food supply chain, were essential to determine the nature of food waste. Is food waste a sum of incidentals in the food supply or is it instead of a structural problem embedded in the food

system? The identified causes were classified as micro causes, meso causes and macro causes following the High Panel of Experts seminal report on food waste. This study has highlighted the importance of meso and macro causes. They are intimately bound up with business and economic stakeholders' interrelationships and to systemic dynamics of food systems. Notwithstanding the structural prevalence of food waste roots, micro-causes were also found such as specific inefficiencies of manufacturing processes or the lack of knowledge and concern as regards as food waste volumes and its consequences, especially consumers.

Within **chapter 2**, the whole-chain approach helped to obtain potential solutions to the structural causes of food waste. Stakeholders proposed solutions to prevent and reduce food waste transcending weak prevention measures. Good examples were educating in values and to value food as well as promoting a strategic food access plan. However, as in previous literature, weak prevention measures obtained greater acceptability as they were perceived as having higher effectiveness to prevent food waste. In particular, a set of measures aimed at increasing consumers' appreciation and enhancement towards food waste.

Chapter 2 addresses, to some extent, the causes of food waste identified in chapter 1. We found a great interest in dealing with food redistribution which has not been usually considered in previous academic publications focused on food waste. In chapter 1 there is a comprehensive set of causes that difficult food redistribution. In chapter 2 stakeholders interest in food redistribution is corroborated as they proposed an extensive list of potential solutions to promote it. Unlike previous studies, stakeholders did not give much prominence to efficiency improvements and technological causes and solutions to prevent and reduce food waste.

Food waste cause analysis has been broadly covered in the literature – despite the partial approaches. However, the research discussing the appropriateness of the different alternatives to prevent and reduce food waste is scarce. **Chapter 2** contributes to the literature not only offering regional stakeholders' solutions to food waste but also discussing the priority of each solution. This study shows the importance of focusing on, primarily, strong prevention solution, secondly on weak prevention measures and, finally on redistribution, following, to a certain extent, the hierarchy of food waste management. Despite recycling alternatives are also covered in previous studies, our panel of stakeholders overlooked these options focusing on prevention and redistribution to human consumption. In this context, further research is needed on the food waste hierarchy both on the whole-supply approaches and at the consumer stage. Moreover, **Chapter 3** findings underpin the lack of knowledge of consumers on distinguishing prevention from reduction waste behaviours.

Chapter 1 and 2 shows the great interest of stakeholders about increasing consumers' awareness about food waste, in line with the increasing peer-reviewed publications on consumers'

food waste and with the central message on the need for prominent food waste reduction campaigns. However, there does not seem to be strong evidences on changes on consumers' concerns and behaviour after a decade of public policies. To significantly reduce food waste generation, the consumers' role should be addressed from alternative perspectives. The second part of this thesis (**chapters 3 and 4**) has been addressed to this issue. **Chapters 3 and 4** offer innovative approaches to understand and accordingly address consumer food waste. **Chapter 3** proposes and validates a multidimensional model including food-related, waste-related and values - environmental concern and materialism- to predict consumers' food waste. **Chapter 4** tests the influence of different frames used in food waste campaigns on consumers' food waste generation.

The direct and positive influence of materialism values on food waste generation and the indirect influence of environmental awareness through waste prevention explained in **Chapter 3** reinforces the findings on **Chapter 1 and 2**. Stakeholders in the first chapters stressed the importance of current consumer values in relation to society as an important macro-cause of food waste and, likewise, suggested as a strong prevention measure to change the current situation. Moreover, **chapter 4** demonstrates the influence of different dimensions (frames) of food waste on consumer perception. These findings support the necessity of more multidimensional studies to better understand food waste generation and, accordingly, design appropriate changes to the current food system dynamics.

Increasing consumers' awareness on food waste by developing campaigns to achieve consumers' food waste reduction was the most effective measure to prevent food waste according to stakeholders in **Chapter 2.** However, little is known on the influence of currently used campaigns' messages on consumers' perceptions and behaviour. **Chapter 4** contributes to this gap by explaining how information influences their food waste perception. The chapter identifies different dimensions that can be used to encourage different food waste categories (i.e. invoking the environment dimension for meat and fish, or the monetary dimension for fruit and vegetables). The chapter also provides relevant information on how to induce consumers to admit greater food waste by using the value of food (economic dimension). Results are of great relevance both for further research as well as for future prevention campaigns.

The consumer module contributes also on the difficult task of measuring consumer food waste. **Chapter 3** shows that there is a high percentage of consumers reporting nothing or almost nothing food waste volume. The model presented in **chapter 3** used a 7-point Likert scale to quantify consumers' food waste generation. The main limitation of the study is precisely, how food waste has been measured. Using self-reported and categorical measurement can make respondents to underestimate the real food waste generation. However, it cannot be demonstrated as there is no specific data on consumers' food waste generation in the case study region at the time of the

survey and the recent publication use different scales of measurement. Other surveys using categorical scales to measure food waste have found similar results. Trying to solve this limitation, **chapter 4** proposes and validates the utility of an alternative continuous scale. The scale presented to participants was a range where consumers, while moving a slider, reported their household food waste. This is the first time, to our knowledge, that a self-reporting survey collects a quantitative (continuous scale) assessment of consumer food waste. The zero-wasters found in the survey were very low compared to other studies. Online convenience surveys offer broad possibilities to collect information about consumers' behaviours. Future research should explore the new continuous scale to obtain a quantitative food waste measurement

Methodological considerations

This thesis contributes to the literature by offering first-hand data on four case studies. All quantitative and qualitative methods used have been proved to be adequate to fulfil the objectives of the thesis. The first part of the thesis used a multi-actor panel along the food supply chain to analyse the causes and solutions of food waste. Considering the heterogeneity of the panel, both in-depth interviews and the Delphi survey were appropriate to collect stakeholders' perceptions. The regional scope approach was also validated as a useful unit of analysis as regards as food waste dynamics. In the second part, two consumer surveys were implemented. For exploring multiple dimensions as predictors of consumer food waste behaviour, the PLS-SEM resulted in the more appropriate statistical method to validate the explorative theoretical model. The survey experiment used in the fourth chapter was key to find out the influence of framings.

Limitations

Most of the limitations of the thesis would be attributed to the methods used as explained in each chapter. The results obtained in each chapter should be interpreted with caution and the extrapolation to other regions is not straightforward since we have used qualitative assessment, semi-quantitative method (Delphi) and convenience sampling for consumer's surveys. However, the results obtained are robust to explain case studies. Moreover, all four chapters incorporate an extensive discussion comparing this thesis findings with previous literature, which offers a broader perspective of the relevance of our findings.

Moreover, the rapid evolution of food waste studies during the past years could have been a threat to the thesis proposed four years ago. During the last four years, the numbers of scientific peer-review publications have increased exponentially, offering a new alternative and critical discussions. In spite of this, this thesis is still innovative, fills the gap in the previous literature and contributes to the current debate. Moreover, recent publications have reinforced the initial objectives of this thesis and have enormously contributed on the discussion of our findings.

The dynamics of the policy debate could also have influenced the interpretation of the results obtained in each case study. It is important to note that, at the time of data collection in each case study, the food waste debate was not so mature as it is now. However, the evolution of stakeholders' perception and policies have not changed at the same speed that the academic research has done.

Finally, any chapter of the thesis highly depends on the conceptual framework of food waste adopted. To avoid problems, the decision in this thesis was to adopt a flexible "food waste concept". Intense debates at policy level have been carried out to define a consensual food waste definition. Fortunate for this thesis, no consensus has been reached yet.

Future research

This thesis contributes to both research and policy debate on understanding the food waste conundrum at different levels. It offers alternative and innovative approaches to address the problem. Nonetheless, it is a small piece on the big jigsaw puzzle of food waste. Many possibilities for further research arise from the thesis findings.

Based on the causes and solutions identified in **chapters 1 and 2**, it would be interesting to carry out further research focusing on specific stages. Having a heterogeneous panel of stakeholders allowed us to offer a multidimensional perspective. Perhaps it is the time now to address each set of measures to prevent and reduce food waste with specific groups of stakeholders who are involved in its implementation.

Regarding the effectiveness of the proposed measures to prevent and reduce food waste, it would be useful to assess their real effectiveness on a real case implementation. Moreover, different actions have been implemented to reduce food waste in the studies region and elsewhere. Comparing the impact those measures have had with case study stakeholders' perceptions could help to clarify the roadmap to policy makers.

The two consumers' studies are experimental in nature. More samples collecting information from other regions or amplifying the sample size will serve to validate and provide robustness to our findings. The consumer theoretical model should be extended by including other variables that have been found in other recent studies as drivers of food waste. In the experimental framing survey, there is a need to use more accurate data on the actual conversion from weight dimension to the others (economic, social and environmental).

Last but not least, further research on the discourses around the food waste concept are needed. Results from this thesis have shown the multidimensional nature of food waste. Therefore, exploring how different discourses influence the perception of the problem would contribute to better understand the phenomenon.