

**Food waste generation in the hospitality and food
service sector: Prevention insights from Malaysia**

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The candidate confirms that the work submitted is her own, except where work which has formed part of jointly-authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

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Three journal papers were written as part of the thesis, and are presented in sequence as the following joint-authored publications:

Chapter	Journal paper
Chapter 2	Papargyropoulou, E., Lozano, R., K. Steinberger, J., Wright, N. & Ujang, Z. Bin. (2014). The Food Waste Hierarchy as a Framework for the Management of Food Surplus and Food Waste. <i>Journal of Cleaner Production</i> , 76, 106–115.
Chapter 3	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. <i>Waste Management</i> , 49 (March), 326–336.
Chapter 4	Papargyropoulou, E., K. Steinberger, J., Wright, N. Lozano, R. and Ujang, Z. Patterns and causes of food waste generation in the hospitality and food service sector: A comparative analysis of five case studies from Malaysia.

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Abstract

Food security is one of the greatest challenges the world faces today. Providing nutritious, safe and affordable food for all in a sustainable way will become even more challenging under the burden of increasing world population and global environmental change. Whilst 795 million people are undernourished; one third of the food produced globally for human consumption is lost or wasted. The food waste – hunger paradox is an illustration firstly of the failing global food system, and secondly of the importance of food waste in the sustainability and food debates. Food waste represents substantial economic losses, has devastating environmental impacts, and moral and ethical implications in the face of food poverty.

Due to its detrimental economic, environmental and social impacts, food waste has received increasing attention in research and policy, viewed predominately from an engineering and technological perspective. In response, this research firstly critically reviewed contemporary conceptual frameworks and reframed food waste to produce the Food Waste Hierarchy. Secondly, it critiqued the current methodological approaches and developed a new framework to investigate the scale, origin, patterns and causes of food waste generation in the hospitality and food service sector in Malaysia. Finally, the research identified the most promising food waste prevention measures for the sector. These objectives were achieved by developing and applying a mixed methods interdisciplinary approach that linked the biophysical and economic flows of food provisioning and waste generation, with the social practices associated with food preparation and consumption. The food waste prevention insights that emerged from this research call for change in both the socio-technical *systems* and social *practices* related to food production and consumption; a message relevant to the food and broader sustainability research.

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Abbreviations

CS – Case Study

DEFRA - Department for Environment, Food and Rural Affairs

EPA - Environmental Protection Agency

EU – European Union

FAO - The Food and Agriculture Organization of the United Nations

FCO - Foreign and Commonwealth Office

FSC - Food Supply Chain

GHG - Green House Gases

GT - Grounded Theory

MFA – Material Flow Analysis

MHLG - Ministry of Housing and Local Government

MSW - Municipal Solid Waste

NGOs - Non-Governmental Organizations

RM – Ringgit Malaysia

SCP- Sustainable Consumption and Production

SRA - Sustainable Restaurant Association

SWPC – Solid Waste and Public Cleansing

UK – United Kingdom

UN – United Nations

UNEP - United Nations Environment Programme

USA – United States of America

USD – United States Dollar

UTM - Universiti Teknologi Malaysia

WBCSD - World Business Council for Sustainable Development

WRAP – Waste and Resources Action Programme

Chapter 1: Introduction

Sustaining the growing global population within the constraints of our planet is one of the biggest challenges humanity faces (Meadows et al., 2004; Bai et al., 2015; Häyhä et al., 2016). In 2015, the United Nations (UN) adopted Agenda 2030, a “*plan for a better future for all*” and agreed on 17 goals for achieving sustainable development (United Nations, 2015). Responsible consumption and production, climate action and zero hunger are three of these sustainable development goals. The zero hunger goal calls for a profound rethink of our food systems, including food waste reduction, to end food insecurity. The climate action goal urges countries to combat climate change and its devastating impacts by reducing Greenhouse Gas (GHG) emissions, including those from our food production, consumption and disposal. The sustainable consumption and production goal draws attention to the wastefulness of our current production and consumption systems and advocates significantly reducing waste generation through prevention, reduction, recycling and reuse. The sustainable development goals highlight the relevance of consumption, food and waste to sustainability debates.

Waste is a global issue; if not dealt with properly waste poses significant threat to human health and the environment (UNEP, 2015). Municipal Solid Waste (MSW) is an important by-product of every city. Every person generates on average 1.2 kg of waste per day, with wide variations between low and high-income countries (UNEP, 2015). MSW generation is growing even faster than the rate of urbanisation itself and global MSW is expected to double by 2025 (The World Bank, 2012). Organic waste makes up the majority of the global MSW, at 46 %, followed by paper, plastic, glass and metals (Figure 1). The main component of the organic waste fraction is food waste, making it a priority waste stream in waste prevention, utilisation and management strategies.

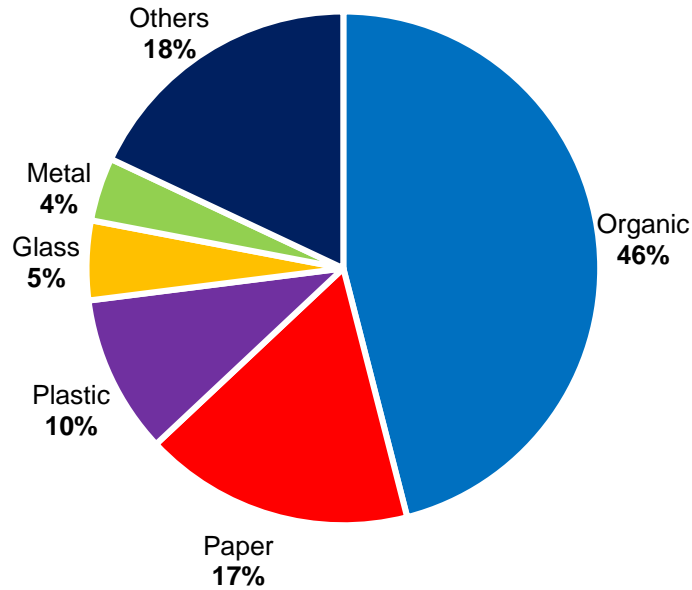


Figure 1: Global Municipal Solid Waste composition

Food waste is defined as edible material intended for human consumption, arising at any point in the Food Supply Chain (FSC) that is instead discarded, lost, degraded or consumed by pests (FAO, 1981). Food is lost or wasted throughout the FSC from the initial stage of agriculture through to the final consumption stage (Smil, 2004). Food losses take place at the production, post-harvest, and processing stages of the FSC, whereas during retail and consumption the term food waste is applied (Gustavsson et al., 2011; Grolleaud, 2002). Food losses in the first part of the FSC due to financial, managerial and technical limitations in harvesting techniques, storage facilities and transport infrastructure are more common in low income countries (Parfitt et al., 2010). The causes of food waste in high income countries relate primarily to consumer behaviour and lack of coordination between different actors in the supply chain (Parfitt and Barthel, 2011). This research closer aligns itself with the FAO food waste definition above, however food waste can be defined in more than one way reflecting the intrinsically interdisciplinary nature of the food waste scholarship. Food waste can be defined as a loss of nutritional value measured in grams of protein, fat, carbohydrates, vitamins and minerals for example (Lee et al., 2015; Serafini et al., 2015), or as a loss of energy measured in kcal or kJ (Buzby and Hyman, 2012), or as a loss of water (Lundqvist et al., 2008) and soil nutrients such as nitrogen (N), phosphorus (P) and potassium (K) absorbed by plants and vegetables but not returned back into the soil after food becomes waste (Smil, 2004).

Regardless of how food waste is framed, the fact remains that one third of food produced globally for human consumption is lost or wasted, which amounts to approximately 1.3 billion tons per year (Gustavsson et al., 2011). At the same time 795

million people are undernourished (FAO et al., 2015). The amount of food lost or wasted would be enough to feed the world's hungry three times over (Stuart, 2009). The food waste – hunger paradox is a powerful illustration firstly of the significance of food waste, and secondly of the fact that food waste is part of a bigger problem that is the failing global food system. This paradox provided the inspiration and motivation for conducting this PhD research.

This introduction aims to situate the thesis in the relevant research fields. Section 1.1 highlights the nature, magnitude and severity of the food waste problem. Section 1.2 provides the Malaysian context and demonstrates why Malaysia is a fascinating place to investigate food waste in the hospitality and food service sector. Section 1.3 discusses the gaps in knowledge within the field of food waste studies. Section 1.4 outlines the aim, design and contributions of the research. A brief account of the PhD research process and challenges are presented in Section 1.5. Finally, the structure of the rest of the Thesis is explained in Section 1.6.

1.1 Economic, environmental and social impacts of food waste

The FAO (2014) estimates that global food losses and waste throughout the FSC represent an annual economic loss of USD 1 trillion. Food and drink wasted in homes that could have been eaten has a retail value of approximately USD165.6 billion in the USA (Buzby and Hyman, 2012). A 20-50% reduction in global consumer food waste could save between USD 120 and 300 billion per year by 2030 (Parry et al., 2015). The Sustainable Restaurant Association (2010) states that food waste costs UK restaurants approximately two to three percent of their turn-over. Food waste has substantial economic impacts to both food producers and consumers (WRAP, 2012; Evans, 2011a). For the smallholders living on the margins of food insecurity, a reduction in food losses could have an immediate and significant impact on their livelihoods (Gustavsson et al., 2011). For consumers affected by food poverty the priority is to have access to food products that are nutritious, safe and affordable. Considering the magnitude of food wastage in the FSC, making profitable investments in reducing losses and waste could be one way of reducing the cost of food (Gustavsson et al., 2011; Lundqvist et al., 2008).

In terms of the environmental impacts of food waste, it is estimated that the waste sector accounts for approximately three percent of global GHG emissions (UNEP, 2010; Stern, 2006). The majority of these emissions originate from the decomposition of organic matter in food waste during disposal. In addition, activities associated with food production such as agriculture (including land use change), processing, manufacturing, transportation, storage, refrigeration, distribution and retail all have an

embedded GHG impact (Tuncer and Schroeder, 2011; Lundqvist et al., 2008; Garnett, 2011; Scholz et al., 2014). Agriculture is associated with nearly 22% of all GHG emissions, with livestock production accounting for approximately 18% of total GHG emissions (Lundqvist et al., 2008; McMichael et al., 2007; Steinfeld et al., 2006). Barrett and Scott (2012) calculate that preventing food waste in the UK has the potential of a 456 million tonnes GHG emission reduction by year 2050. WRAP (2011b) estimates that avoidable food waste led to 17 million tonnes of CO₂ eq. in 2010, equivalent to the emissions of 1 in 5 cars on UK roads. Other environmental impacts of food waste include natural resources depletion, such as soil nutrients, water and energy (Abeliotis et al., 2015), the disruption of the biogenic cycles of nitrogen and phosphorus used in agriculture as fertilizers (Rockström et al., 2009; Smil, 2002; Kummu et al., 2012), and environmental pollution throughout the FSC (Lundie and Peters, 2005).

The social impacts of food waste focus on the ethical and moral dimensions of wasting food in the face of global food insecurity (Edwards and Mercer, 2007; Evans, 2011a). Achieving food security is a complex challenge with environmental, social, political and economic determinants, particularly of food availability, stability, access and utilisation (Ingram, 2011; Ericksen, 2008; Schmidhuber and Tubiello, 2007). Inequalities in access to the global FSC exist between affluent and poorer countries, and also within individual countries as the rise of food charities in high income countries suggest (Midgley, 2013; Wrigley, 2002). Disparities in global food distribution have given rise to a situation whereby 1.4 billion people are overweight or obese, while 795 million are undernourished (FAO et al., 2015; Swinburn et al., 2011). The paradox of food waste and food poverty emphasises the social and ethical implications of wasting food, and highlights the fact that preventing food waste can play a part in achieving food security (Godfray et al., 2010).

1.2 Studying food waste in the Malaysian context

This section provides essential context about Malaysia's status in terms of development, the changing consumption patterns, as well as the current state of solid waste management policy and practice. It demonstrates why Malaysia, and Kuala Lumpur, in particular is a relevant place to study food waste in the hospitality and food service sector.

1.2.1 Economic development, urbanisation and consumption

The World Bank classifies Malaysia as an upper middle income country (The World Bank, 2016). Although in 2015 Malaysia's economy slowed down due to a drop in fossil fuel prices, the country had an average annual economic growth of more than 7%

during the past 25 years (The World Bank, 2015b). Malaysia aspires to reach high income status by 2020 while ensuring that growth is also sustainable and inclusive (Economic Planning Unit, 2016; National Economic Advisory Council, 2010). This economic growth has been coupled with rapid urbanisation (4% yearly urban population growth between 2000 and 2010), making Malaysia one of the most urbanised countries in East Asia (The World Bank, 2015a). Consumption has followed a similar trajectory, with household consumption expenditure tripling in the last 15 years (Department of Statistics Malaysia, 2015).

This particular mix of socio-economic conditions (economic growth, urbanisation and consumption acceleration) place Malaysia in a crucial point in its developmental path. Recent research identifies middle income countries as the ideal cases for low-carbon development (Gouldson et al., 2015) offering substantial opportunities to leapfrog and avoid the environmental destruction industrialised countries have caused in their quest for growth (Levin and Thomas, 2016). The way Malaysia negotiates trade-offs between economic growth and environmental and social priorities has the potential to lead to long term sustainability.

1.2.2 Kuala Lumpur, the (food) capital of Malaysia

Kuala Lumpur is Malaysia's capital and most populous city¹. It features iconic landmarks such as the Twin Towers (owned by Petronas, the Malaysian national oil company) and represents the face of modern Malaysia (Pemandu, 2012). Kuala Lumpur is a political, financial and economic hub for Malaysia and one of the fastest growing cities in the Asia Pacific (Euromonitor International, 2016). In 2014 it accounted for 38% of the national GDP, making it the country's centre of economic activity and growth (Euromonitor International, 2016). Kuala Lumpur is also rich in history and cultural heritage, making it a major tourist destination (Malaysia Tourism Board, 2014). One of the most popular city attractions is the diverse and unique food scene, ranging from street food to fine dining and from local traditional dishes to international award winning cuisine (Smillie, 2010) making Kuala Lumpur the food capital of Malaysia (Hawkes, 2015).

1.2.3 Food and waste in Malaysia

Food is a central part of any culture, since it reflects the social and economic structure of society and is intrinsically linked to peoples' identity (Bisogni et al., 2002; Almerico,

¹ The population of Greater Kuala Lumpur was six million in 2010 (Pemandu, 2012).

2014). This is the case for Malaysia too, where the common greeting “*sudah makan?*” means “*have you eaten?*”. In a multi-cultural country like Malaysia food unities, and at times divides, the three main ethnic groups of Malay, Chinese and Indian (Ying and Karim, 2016) (Figure 2). In addition, partially due to government subsidies, the proliferation of restaurants, cafes and food stalls reflects the relatively low cost of food, meaning the majority of the population can afford to eat out rather than prepare food at home (Malaysian - German Chamber of Commerce, 2012). It is therefore important to recognise that in Malaysia the hospitality and foodservice sector is rapidly overtaking the household as the biggest source of food waste. This unique feature made Malaysia a fascinating setting to study food waste within the hospitality and food service sector.

Food waste accounts for nearly half the waste generated in Malaysia (Figure 3) with some studies estimating it to be as much as 59% of the total waste (Zainon Noor et al., 2013). Thus food waste offers considerable opportunities for waste reduction, recycling and energy recovery (Kathirvalem et al., 2003). Food waste prevention debates in Malaysia centre around the obligation of the individual to act, relinquishing any responsibility of the government and the production and consumption systems in place that lead to food waste generation in the first place (for the individualisation of environmental responsibility see Shove, 2010; Clapp, 2002; Maniates, 2001). On the other hand, food waste is presented as a renewable energy source that can meet Malaysia’s future energy demands (Fazeli et al., 2016).



(a)



(b)



(c)



(d)



(e)



(f)

Figure 2: Lunch by the river (a), the street (b, c, d) or a luxurious hotel (e, f): the many faces of food consumption in Malaysia (Papargyropoulou, 2013b)

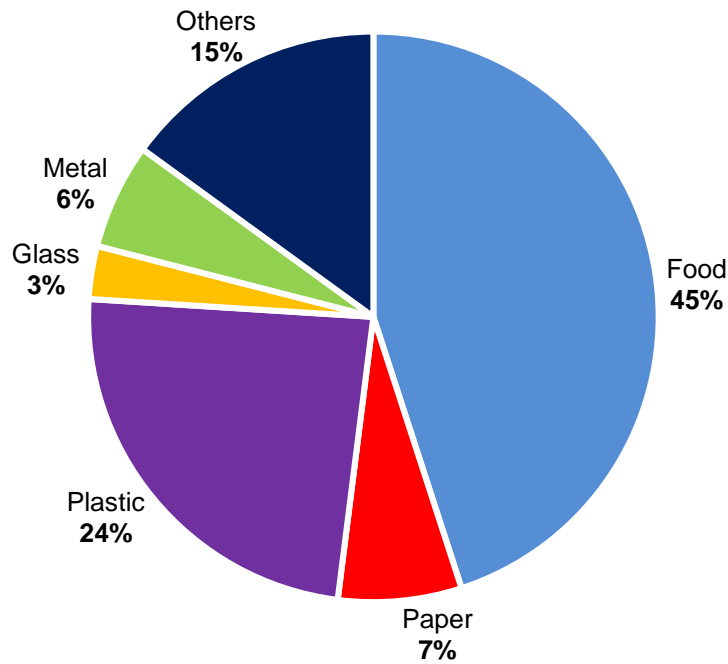


Figure 3: Malaysia's Municipal Solid Waste composition (Ministry of Housing and Local Government Malaysia, 2012)

1.2.4 Solid waste management

The management of municipal solid waste remains a challenge for Malaysia, especially in rapidly expanding urban centres (Latifah et al., 2009). Municipal solid waste generation increased by 50% between 1996 and 2006 due to rapid economic development, urbanisation, increase in per capita income and change in consumption patterns (Agamuthu et al., 2009). The waste generation per capita rate continues to rise (Thi et al., 2015). Reliable data on waste generation and management practices is not always available, and most published data relies on estimates (Latifah et al., 2009). The majority of solid waste (75%) is disposed in landfills or unsanitary dumpsites, an estimated 20% is burned or dumped in rivers and illegal sites, and only an estimated five percent is recycled (Agamuthu and Fauziah, 2011). The inadequate and inefficient waste management systems pose environmental problems such as groundwater and river water contamination, environmental pollution, GHG emissions contributing to global warming, and health risks from vector-borne diseases (Meidiana and Gamse, 2010).

The Solid Waste and Public Cleansing Act (SWPC Act) adopted in 2007 is the main policy instrument dealing with solid waste management in Malaysia. It took ten years for the SWPC Act to be finalised and it only came into force in 2016, nine years after its adoption (Agamuthu et al., 2009). These delays in the development and implementation of the SWPC Act are indicative of the challenges Malaysia is facing in

terms of solid waste management governance. The SWPC Act outlines the strategy for waste collection, treatment and final disposal, removes the responsibility for waste management from the Local Authorities and places it under the Federal Government via the Solid Waste and Public Cleansing Management Corporation. It sets ambitious targets for waste separation at source, 22% recycling, 40% diversion of waste from landfill to energy from waste facilities, and closure or upgrading of all unsanitary landfills by 2020 (Laws of Malaysia, 2007). Progress towards achieving these targets has been so far slow (Latifah et al., 2009).

1.3 The rise of food waste studies in academic research

Due to its detrimental economic, environmental and social impacts, food waste has received increasing attention in academic research (Chen et al., 2016) and environmental policy (food waste literature is critically reviewed in Sections 2.3, 2.4, 3.3, and 4.3). Food waste is viewed predominately from a technical and engineering perspective using quantitative methods to 'measure' and 'manage' the 'food waste problem' with technological solutions (Bernstad and la Cour Jansen, 2011). Food waste prevention is considered as the best option to tackle food waste, however it is neglected in academic research with some noteworthy exceptions (Graham-Rowe et al., 2014; Garrone et al., 2014). Alternative approaches from sociology (Evans, 2011b), geography (Warshawsky, 2015), consumption (Leray et al., 2016), business (Goggins and Rau, 2015) and behaviour studies (Lazell, 2016) are emerging and making significant contributions in understanding the process and causes of food waste generation while using qualitative methods. These studies predominately focus on developed countries (Thi et al., 2015), the 'micro' level such as the household (Chen et al., 2016) or the 'macro' level such as the waste management policy (Secondi et al., 2015). This research aims to fill in the gap in literature by investigating food waste prevention at the 'meso' level, such as the hospitality and food service sector, by combining quantitative and qualitative methods and approaches.

1.4 Research aim, design and contribution

The aim of the PhD research is to understand why, how, how much and by whom food waste is generated in the hospitality and food service sector, and subsequently identify the most promising opportunities for food waste prevention. In this pursuit, the context, sources, causes and patterns of food waste generation are examined in case studies from the hospitality and food service sector in Kuala Lumpur, Malaysia.

The overarching research question of this research is:

'What are the most promising measures for food waste prevention in the hospitality and food service sector in Kuala Lumpur, Malaysia, based on a comprehensive assessment of the context, causes, patterns and scale of food waste generation?'

This main research question is approached by addressing four sub-questions, which are designed to build upon each other.

RQ1: What is the most suitable conceptual and policy framework for the management of food surplus and food waste?

RQ2: What is the most appropriate conceptual framework for the study of food waste generation and prevention in the hospitality and food service sector, and how could it be implemented in practice?

RQ3: What patterns, causes and scale of food waste generation can be identified in the hospitality and food service sector in Kuala Lumpur?

RQ4: What are the most advantageous food waste preventions measures generation in the hospitality and food service sector in Malaysia?

1.4.1 Research design

Guided by the research aim, the design was structured around four objectives corresponding to the four research questions presented in the section above (Figure 4.) The research began by reframing food waste drawing on concepts and frameworks such as the Waste Hierarchy, and Sustainable Consumption and Production. The strengths and applications of approaches, methods and tools from waste management, industrial ecology, ethnography and Grounded Theory were evaluated and a novel mixed methods framework for the study of food waste was developed. The methodological framework was tested within five case studies from the hospitality and food service sector in Kuala Lumpur, Malaysia (for details on the case studies and the criteria of their selection refer to Chapter 3). The outcomes from the case studies were reflected upon to develop recommendations for food waste prevention. The mixed methods case study research design connected the biophysical and economic flows of food provisioning and waste generation, with the social and cultural practices associated with food preparation and consumption.

Research Aim	Understand why, how, how much and by whom food waste is generated in the hospitality and food service sector, and identify the most promising opportunities for food waste prevention			
Research Questions	RQ1	RQ2	RQ3	RQ4
Research Objectives	To reframe food waste and address the weaknesses of contemporary conceptual frameworks	To critique methodological approaches to food waste and develop new framework to study food waste	To investigate food waste generation: scale, origin, patterns, causes	To propose food waste prevention measures
Methods & Concepts	<ul style="list-style-type: none"> • Critical review of: <ul style="list-style-type: none"> i. Sustainable Consumption and Production ii. Waste Hierarchy • Semi-structured and in-depth interviews • Data analysis with the use of Grounded Theory techniques 	<ul style="list-style-type: none"> • Review of strengths and applications of approaches, methods and tools from: <ul style="list-style-type: none"> i. Industrial ecology ii. Ethnography iii. Grounded theory iv. Waste management • Test of new methodological framework in case study 	<ul style="list-style-type: none"> • Waste audit: <ul style="list-style-type: none"> i. Food waste weight ii. Composition iii. Avoidable / unavoidable iv. Origin • Interviews • Focus groups • Participant observation • Material and economic flow analysis • Eco-efficiency calculation • Grounded Theory & constant comparative analysis: explanation of emerging patterns and relationships among data 	<ul style="list-style-type: none"> • Identify and understand causes of food waste generation • Review industry examples of best and bad practice • Tailor food waste prevention measures to target specific waste generation causes • Focus groups to evaluate applicability of measures
Output	The Food Waste Hierarchy as a framework for the management of food surplus and food waste	Mixed methods framework for the study of food waste generation and prevention in the hospitality and food service sector	Empirical data on food waste generation: scale, origin, patterns, causes	Food waste prevention recommendations for the hospitality and food service sector
Location in thesis	Chapter 2	Chapter 3	Chapter 4	Chapter 4

Figure 4: Research design

1.4.2 *Mixed methods*

Data collection and analysis methods from ethnography and Grounded Theory were complemented with concepts and tools from industrial ecology and waste management for the analysis of quantitative data. The quantitative data collection methods comprised of a food waste audit, photographic records, collection of financial records, and inventory of food purchases. Data analysis methods included material and economic flow analyses, and calculation of eco-efficiency ratios. Quantitative methods assessed the amount and type of food purchased and measured the food waste generated to prioritise the most promising measures for waste prevention. This evidence guided the waste minimisation strategy by informing where the focus should be and which measures could have a greater impact in reducing food waste.

Qualitative data collection methods included interviews, participant observation and focus groups (Figure 5). Qualitative data explained the patterns and causes of food waste. Grounded Theory was used in the process of reframing food waste, the analysis of qualitative data from interviews, participant observation, focus groups and literature review, the critical reflection on the case studies' outcomes, and development of food waste prevention recommendations. The investigation of food waste generation and prevention was based on the inductive and iterative process of the constant comparative analysis method in which theory was built and modified from the data collected (for details on how Grounded Theory and the constant comparative analysis were applied see Chapter 3).



Figure 5: Data collection: interviews, waste audits and focus groups (Papargyropoulou, 2013a)

1.4.3 Threats to validity and reliability

In ensuring a robust research design, certain strategies were employed to satisfy the four tests commonly used in establishing the quality of empirical research namely reliability, construct, internal and external validity (Kidder and Judd, 1986; Yin, 2009). Table 1 presents the strategies employed to satisfy these four tests. During the data collection stage the use of multiple sources of evidence ensured construct validity, and the use of a case study protocol established reliability. A replication logic (not sampling logic) was used when selecting case studies as a means to achieve analytical

generalisation (not statistical generalisation) (For definitions of generalisation and replication logic see Yin, 2009). Addressing rival explanations helped establish internal validity.

Table 1: Strategies to ensure validity and reliability in the research (Yin, 2009; Jupp, 2006)

Tests	Research strategies	Research phase when strategy is employed
Construct validity: the extent to which an indicator or variable adequately measures the theoretical concept it intends to	Use multiple sources of evidence-triangulation Establish chain of evidence	Data collection
Internal validity: the extent to which an explanation of how and why some phenomenon occurs is the correct one	Do explanation building Address rival explanations	Data analysis
External validity: the extent to which information from a sample gives us information about the population, or extent to which information about one setting tells us about others	Develop and use a replication logic for multiple case studies	Research design, data collection and analysis
Reliability: the extent to which a measuring instrument or technique gives consistent results	Develop and use a case study protocol Select typical subjects, representative of the total population Carry out study at different times and days of the week Apply a 'habituation' strategy	Data collection

The limited amount of time allocated for PhD research and obstacles in gaining access to the hospitality and food service sector posed certain limitations to this research. Access issues were resolved following networking efforts with hospitality and food service sector stakeholders and establishment of mutual trust and common goals.

1.4.4 *Research contribution*

This research made contributions to the waste management field and the Sustainable Consumption and Production debates. The research reframed food waste and

produced the Food Waste Hierarchy, it provided new empirical data on the scale, origin, patterns and causes of food waste, and identified the most promising food waste prevention measures for the hospitality and food service sector. This was achieved by developing a mixed methods interdisciplinary approach that linked the biophysical and economic flows of food provisioning and waste generation, with the social practices associated with food provisioning and consumption. The food waste prevention insights that emerged from this research call for a change both in the socio-technical systems and social practices related to food production and consumption; a message relevant to the food and broader sustainability research.

1.5 The PhD research journey

The journey for this PhD research began when I moved from the UK to Malaysia and the different ways in which people consumed food and generated food waste became apparent; the average Malaysian ate most of their meals outside their home and over half of the municipal solid waste was food waste. Having a background in waste and environmental management I began investigating the phenomenon of food waste from a technical perspective, focusing more on the aspects that could be measured. Tools and approaches from industrial ecology fitted comfortably within the context of waste management research.

However, the more I read the food waste literature and the more I observed food waste generation, it became obvious that solely quantitative methods were not sufficient to answer questions of 'why', 'how', and 'by whom'. At that point I ventured into unknown 'territories' for me, such as in sociology, geography, psychology, economics, and studies of organisational theory, ethnography and grounded theory. Not all of these 'territories' ended up being part of the final thesis, not explicitly at least, however I did use qualitative methods, tools and approaches often applied in these disciplines and types of research.

Moving away from waste management, acknowledging the limitations of my own discipline, and complementing it with different approaches, made for a truly interdisciplinary research. However, the integration of all of these tools, methods, and approaches was challenging both from a practical and epistemological point of view. In practice, the measurement of the food waste weight, the recording of the contents of the buffet leftover, the observation of the customers' food consumption practices and the informal discussions with the kitchen staff were happening concurrently, shaping the data collection and analysis direction in a dynamic way. I had to acknowledge that the qualitative and quantitative methods and approaches used in this research sprung from different epistemological traditions; however, when combined they offered a new

perspective and therefore were necessary to obtain a richer and more comprehensive picture of the food waste phenomenon.

1.6 Thesis structure

Chapter 1 locates the PhD research to its relevant research fields, states the aim of the research, and briefly describes the overall research design and methods used in data collection and analysis. Chapters 2, 3 and 4 present the three manuscripts that form the core of the thesis. Chapter 5 binds the three manuscripts together by discussing the PhD's novel contribution to knowledge and its implications for research, policy and the hospitality and food service sector. The structure of the thesis, the function and focus of each chapter are summarised in Table 2.

Table 2: Thesis structure

Chapter	Function	Focus
Chapter 1	Introduction	Positioning of research Aim of research Brief research design and methods
Chapter 2	Published manuscript 1: Papargyropoulou, E., Lozano, R., K. Steinberger, J., Wright, N. & Ujang, Z. Bin. (2014). The Food Waste Hierarchy as a Framework for the Management of Food Surplus and Food Waste. <i>Journal of Cleaner Production</i> , 76, 106–115	Theoretical background and conceptual framework for the research
Chapter 3	Published manuscript 2: 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. <i>Waste Management</i> , 49 (March), 326–336.	Methodological approach and research design
Chapter 4	Manuscript 3: Papargyropoulou, E., K. Steinberger, J., Wright, N. Lozano, R. and Ujang, Z. Patterns and causes of food waste generation in the hospitality and food service sector: A comparative analysis of five case studies from Malaysia.	Data analysis Results and findings Recommendations
Chapter 5	Discussion and Conclusions	Implications of the research Unique contribution to knowledge

1.7 References

Abeliotis, K., Lasaridi, K., Costarelli, V. & Chroni, C. (2015). The Implications of Food

Waste Generation on Climate Change: The Case of Greece. *Sustainable Production and Consumption*, 3(March), 8–14. Retrieved from <http://dx.doi.org/10.1016/j.spc.2015.06.006>

Agamuthu, P., Fauziah, H. S. & Khidzir, K. (2009). Evolution of Solid Waste Management in Malaysia: Impacts and Implications of the Solid Waste Bill, 2007. *Journal of Material Cycles and Waste Management*, 11(2), 96–103. Retrieved April 4, 2012, from <http://www.springerlink.com/index/10.1007/s10163-008-0231-3>

Agamuthu, P. & Fauziah, S. H. (2011). Challenges and Issues in Moving towards Sustainable Landfilling in a Transitory Country - Malaysia. *Waste management & research: the journal of the International Solid Wastes and Public Cleansing Association, ISWA*, 29(1), 13–9. Retrieved May 25, 2014, from <http://www.ncbi.nlm.nih.gov/pubmed/20880936>

Almerico, G. M. (2014). Food and Identity: Food Studies, Cultural, and Personal Identity. *Journal of International Business and Cultural Studies*, 8, 1–7. Retrieved from <http://www.aabri.com/manuscripts/141797.pdf>

Bai, X., van der Leeuw, S., O'Brien, K., Berkhout, F., Biermann, F., Brondizio, E. S., et al. (2015). Plausible and Desirable Futures in the Anthropocene: A New Research Agenda. *Global Environmental Change*, 39, 351–362. Retrieved from <http://dx.doi.org/10.1016/j.gloenvcha.2015.09.017>

Barrett, J. & Scott, K. (2012). Link between Climate Change Mitigation and Resource Efficiency: A UK Case Study. *Global Environmental Change*, 22(1), 299–307. Retrieved May 16, 2012, from <http://linkinghub.elsevier.com/retrieve/pii/S0959378011001907>

Bernstad, A. & la Cour Jansen, J. (2011). A Life Cycle Approach to the Management of Household Food Waste - A Swedish Full-Scale Case Study. *Waste Management*, 31(8), 1879–1896. Retrieved from <http://dx.doi.org/10.1016/j.wasman.2011.02.026>

Bisogni, C. A., Connors, M., Devine, C. M. & Sobal, J. (2002). Who We Are and How We Eat : A Qualitative Study of Identities in Food Coice. *Journal of Nutrition Education and Behavior*, 34, 128–139.

Buzby, J. C. & Hyman, J. (2012). Total and per Capita Value of Food Loss in the United States. *Food Policy*, 37, 561–570. Retrieved from <http://dx.doi.org/10.1016/j.foodpol.2012.06.002>

Chen, H., Jiang, W., Yang, Y., Yang, Y. & Man, X. (2016). State of the Art on Food

Waste Research: A Bibliometrics Study from 1997 to 2014. *Journal of Cleaner Production*. Retrieved from <http://www.sciencedirect.com/science/article/pii/S095965261501803X>

Clapp, J. (2002). Distancing of Waste: Overconsumption in a Global Economy, in: Princen, T., Maniates, M., and Conca, K. (Eds.), *Confronting Consumption*, (pp. 155–177). Massachusetts: MIT Press.

Department of Statistics Malaysia. (2015). Report on Household Expenditure Survey 2014. Retrieved from <https://www.statistics.gov.my>

Economic Planning Unit. (2016). Eleventh Malaysia Plan 2016-2020.

Edwards, F. & Mercer, D. (2007). Gleaning from Gluttony: An Australian Youth Subculture Confronts the Ethics of Waste. *Australian Geographer*, 38(3), 279–296. Retrieved July 4, 2012, from <http://www.tandfonline.com/doi/abs/10.1080/00049180701639174>

Ericksen, P. J. (2008). Conceptualizing Food Systems for Global Environmental Change Research. *Global Environmental Change*, 18(1), 234–245.

Euromonitor International. (2016). Kuala Lumpur City Review. Retrieved from <http://www.euromonitor.com/kuala-lumpur-city-review/report>

Evans, D. (2011a). Thrifty, Green or Frugal: Reflections on Sustainable Consumption in a Changing Economic Climate. *Geoforum*, 42(5), 550–557. Retrieved March 14, 2012, from <http://linkinghub.elsevier.com/retrieve/pii/S0016718511000443>

Evans, D. (2011b). Beyond the Throwaway Society: Ordinary Domestic Practice and a Sociological Approach to Household Food Waste. *Sociology*, 46(1), 41–56. Retrieved March 10, 2012, from <http://soc.sagepub.com/cgi/doi/10.1177/0038038511416150>

FAO. (1981). *Food Loss Prevention in Perishable Crops*. Rome: Food and Agriculture Organization of the United Nations, Agricultural Service Bulletin, no. 43, FAO Statistics Division.

FAO. (2014). *Global Initiative on Food Losses and Waste Reduction*. Rome.

FAO, IFAD & WFP. (2015). *The State of Food Insecurity in the World: Meeting the 2015 International Hunger Targets: Taking Stock of Uneven Progress*. Retrieved from <http://www.fao.org/3/a4ef2d16-70a7-460a-a9ac-2a65a533269a/i4646e.pdf>

Fazeli, A., Bakhtvar, F., Jahanshaloo, L., Che Sidik, N. A. & Bayat, A. E. (2016). *Malaysia's Stand on Municipal Solid Waste Conversion to Energy: A Review*.

Renewable and Sustainable Energy Reviews, 58, 1007–1016. Retrieved from <http://dx.doi.org/10.1016/j.rser.2015.12.270>

- Garnett, T. (2011). Where Are the Best Opportunities for Reducing Greenhouse Gas Emissions in the Food System (Including the Food Chain)? *Food Policy*, 36, S23–S32. Retrieved September 23, 2013, from <http://linkinghub.elsevier.com/retrieve/pii/S0306919210001132>
- Garrone, P., Melacini, M. & Perego, A. (2014). Opening the Black Box of Food Waste Reduction. *Food Policy*, 46, 129–139. Retrieved from <http://dx.doi.org/10.1016/j.foodpol.2014.03.014>
- Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., Pretty, J., Robinson, S., Thomas, S. M., Toulmin, C. (2010). Food Security: The Challenge of Feeding 9 Billion People. *Science (New York, N.Y.)*, 327(5967), 812–8. Retrieved from <http://www.sciencemag.org/content/327/5967/812.abstract>
- Goggins, G. & Rau, H. (2015). Beyond Calorie Counting: Assessing the Sustainability of Food Provided for Public Consumption. *Journal of Cleaner Production*. Retrieved from <http://linkinghub.elsevier.com/retrieve/pii/S0959652615007647>
- Gouldson, A., Colenbrander, S., Sudmant, A., McAnulla, F., Kerr, N., Sakai, P., et al. (2015). Exploring the Economic Case for Climate Action in Cities. *Global Environmental Change*, 35, 93–105. Retrieved from <http://dx.doi.org/10.1016/j.gloenvcha.2015.07.009>
- Graham-Rowe, E., Jessop, D. C. & Sparks, P. (2014). Identifying Motivations and Barriers to Minimising Household Food Waste. *Resources, Conservation and Recycling*, 84, 15–23. Retrieved from <http://dx.doi.org/10.1016/j.resconrec.2013.12.005>
- Grolleaud, M. (2002). Post-Harvest Losses: Discovering the Full Story. Overview of the Phenomenon of Losses during the Post-Harvest System. Rome: FAO, Agro Industries and Post-Harvest Management Service.
- Gustavsson, J., Cederberg, C., Sonesson, U., Otterdijk, R. van & Meybeck, A. (2011). *Global Food Losses and Food Waste. Extent, Causes and Prevention*. Rome.
- Hawkes, W. (2015). Kuala Lumpur's Street Food Scene. Independent. Retrieved November 2, 2016, from <http://www.independent.co.uk/travel/asia/kuala-lumpurs-street-food-not-a-scene-more-a-way-of-life-10277010.html>
- Häyhä, T., Lucas, P. L., van Vuuren, D. P., Cornell, S. E. & Hoff, H. (2016). From

Planetary Boundaries to National Fair Shares of the Global Safe Operating Space. How Can the Scales Be Bridged? *Global Environmental Change*, 40, 60–72.

Ingram, J. (2011). A Food Systems Approach to Researching Food Security and Its Interactions with Global Environmental Change. *Food Security*, 3(4), 417–431.

Jupp, V. (2006). *The SAGE Dictionary of Social Research Methods* (V. Jupp, Ed.). London: SAGE Publications Ltd.

Kathirvale, S., Muhd Yunus, M. N., Sopian, K. & Samsuddin, A. H. (2003). Energy Potential from Municipal Solid Waste in Malaysia. *Renewable Energy*, 29(4), 559–567. Retrieved March 11, 2012, from <http://linkinghub.elsevier.com/retrieve/pii/S0960148103002969>

Kidder, L. & Judd, C. M. (1986). *Research Methods in Social Relations*. New York: Holt, Rinehart & Winston.

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. *Science of the Total Environment*, 438, 477–489. Retrieved from <http://dx.doi.org/10.1016/j.scitotenv.2012.08.092>

Latifah, A. M., Samah, M. A. A. & Nur Ilyana, M. Z. (2009). Municipal Solid Waste Management in Malaysia: Practices and Challenges. *Waste management*, 29(11), 2902–6. Retrieved March 11, 2012, from <http://www.ncbi.nlm.nih.gov/pubmed/19540745>

Laws of Malaysia. (2007). *Solid Waste and Public Cleansing Management Act 2007*. Kuala Lumpur.

Lazell, J. (2016). Consumer Food Waste Behaviour in Universities: Sharing as a Means of Prevention. *Journal of Consumer Behaviour*. Retrieved from doi: 10.1002/cb.1581

Lee, T.K., Serafini, M., Toti, E., Bucatariu, C., Fonseca, J.M., Otterdijk, R. Van and Njie, D. 2015. Determination of Micro-nutrient Losses in Food Losses and Waste (FLW) in Norway and Kenya In: First International Congress on Postharvest Loss Prevention - United Nations Food and Agriculture Organization. October 2015. Rome. Leray, L., Sahakian, M. & Erkman, S. (2016). Understanding Household Food Metabolism: Relating Micro-Level Material Flow Analysis to Consumption Practices. *Journal of Cleaner Production*.

Levin, T. & Thomas, V. M. (2016). Can Developing Countries Leapfrog the Centralized

Electrification Paradigm? *Energy for Sustainable Development*, 31, 97–107.
Retrieved from <http://dx.doi.org/10.1016/j.esd.2015.12.005>

Lundie, S. & Peters, G. M. (2005). Life Cycle Assessment of Food Waste Management Options. *Journal of Cleaner Production*, 13(3), 275–286. Retrieved March 17, 2012, from <http://linkinghub.elsevier.com/retrieve/pii/S0959652604000952>

Lundqvist, J., Fraiture, C. de & Molden., D. (2008). *Saving Water: From Field to Fork Curbing Losses and Wastage in the Food Chain*. Stockholm.

Malaysia Tourism Board. (2014). *Tourism Malaysia. 2014 Annual Report*. Kuala Lumpur. Retrieved from http://www.tourism.gov.my/pdf/uploads/activities/Tourism_AR2014_FA.pdf

Malaysian - German Chamber of Commerce. (2012). *Market Watch 2012. The Malaysian Food Industry*. Kuala Lumpur.

Maniates, M. F. (2001). Individualization: Plant a Tree, Buy a Bike, Save the World? *Global Environmental Politics*, 1(3), 31–52.

McMichael, A. J., Powles, J. W., Butler, C. D. & Uauy, R. (2007). Food, Livestock Production, Energy, Climate Change, and Health. *The Lancet*, 370(9594), 1253–1263.

Meadows, D., Randers, J. & Meadows, D. (2004). *Limits to Growth. The 30-Year Update*. UK: Earthscan.

Meidiana, C. & Gamse, T. (2010). Development of Waste Management Practices in Indonesia. *European Journal of Scientific Research*, 40(2), 199–210.

Midgley, J. L. (2013). The Logics of Surplus Food Redistribution. *Journal of Environmental Planning and Management*, (March 2015), 1–21. Retrieved from <http://www.tandfonline.com/doi/abs/10.1080/09640568.2013.848192>

Ministry of Housing and Local Government Malaysia. (2012). *National Solid Waste Management Department*. Retrieved from www.kpkt.gov.my

National Economic Advisory Council. (2010). *New Economic Model for Malaysia*. Kuala Lumpur.

Papargyropoulou, E. (2013a). *Eating out in Malaysia*. Malaysia: Unpublished photograph.

Papargyropoulou, E. (2013b). *Conducting Food Waste Research in Malaysia*.

Malaysia: Unpublished photograph.

- Parfitt, J. & Barthel, M. (2011). Foresight Project on Global Food and Farming Futures Science Review: SR56 Global Food Waste Reduction: Priorities for a World in Transition. London.
- Parfitt, J., Barthel, M. & Macnaughton, S. (2010). Food Waste within Food Supply Chains: Quantification and Potential for Change to 2050. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, 365(1554), 3065–81. Retrieved March 9, 2012, from <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2935112&tool=pmcentrez&rendertype=abstract>
- Parry, A., James, K. & LeRoux, S. (2015). *Strategies to Achieve Economic and Environmental Gains by Reducing Food Waste*. Banbury.
- Pemandu. (2012). Developing Greater Kuala Lumpur/Klang Valley as an Engine of Economic Growth, in: *Economic Transformation Programme. A Roadmap For Malaysia*, (pp. 123–162). Kuala Lumpur.
- Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin Iii, F. S., Lambin, E. F., et al. (2009). A Safe Operating Space for Humanity. *Nature*, 461, 472–475.
- Schmidhuber, J. & Tubiello, F. N. (2007). Global Food Security under Climate Change. *Proceedings of the National Academy of Sciences of the United States of America*, 104(50), 19703–8. Retrieved from <http://www.pnas.org/content/104/50/19703.short>
- Scholz, K., Eriksson, M. & Strid, I. (2014). Carbon Footprint of Supermarket Food Waste. *Resources, Conservation and Recycling*, 94, 56–65. Retrieved from <http://dx.doi.org/10.1016/j.resconrec.2014.11.016>
- Secondi, L., Principato, L. & Laureti, T. (2015). Household Food Waste Behaviour in EU-27 Countries: A Multilevel Analysis. *Food Policy*, 56, 25–40. Retrieved from <http://www.sciencedirect.com/science/article/pii/S0306919215000858>
- Serafini, M., Lee, W.T.K., Toti, E., Bucatariu, C., Fonseca, J.M., Otterdijk, R. Van and Njie, D. 2015. Global Variations in Micro-nutrient Losses in the Fruit and Vegetables Supply Chain In: *First International Congress on Postharvest Loss Prevention - United Nations Food and Agriculture Organization*. October 2015. Rome.
- Shove, E. (2010). *Beyond the ABC: Climate Change Policy and Theories of Social*

Change. *Environment and Planning A*, 42(6), 1273–1285. Retrieved from <http://www.envplan.com/abstract.cgi?id=a42282>

Smil, V. (2002). Nitrogen and Food Production: Proteins for Human Diets. *Ambio: A Journal of the Human Environment*, 31(2), 126–131.

Smil, V. (2004). Improving Efficiency and Reducing Waste in Our Food System. *Environmental Sciences*, 1(1), 17–26.

Smillie, S. (2010). Malaysia Travel Food and Drink. *The Guardian*. Retrieved October 20, 2016, from <https://www.theguardian.com/lifeandstyle/wordofmouth/2010/dec/28/malaysia-travel-food-and-drink>

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. & De Haan, C. (2006). *Livestock's Long Shadow: Environmental Issues and Options*. Rome: FAO Publishing.

Stern, N. (2006). *Stern Review: The Economics of Climate Change*. London: HM Treasury.

Stuart, T. (2009). *Waste. Uncovering the Global Food Scandal*. London: Penguin.

Sustainable Restaurant Association. (2010). *Too Good to Waste. Restaurant Food Waste Survey Report*. London.

Swinburn, B. A., Sacks, G., Hall, K. D., McPherson, K., Finegood, D. T., Moodie, M. L., et al. (2011). The Global Obesity Pandemic: Shaped by Global Drivers and Local Environments. *The Lancet*, 378(9793), 804–814. Retrieved from [http://dx.doi.org/10.1016/S0140-6736\(11\)60813-1](http://dx.doi.org/10.1016/S0140-6736(11)60813-1)

The World Bank. (2012). *What a Waste: A Global Review of Solid Waste Management*.

The World Bank. (2015a). *Malaysia Economic Monitor. Statewide Agricultural Land Use Baseline 2015*.

The World Bank. (2015b). *East Asia's Changing Urban Landscape - Measuring a Decade of Spatial Growth*.

The World Bank. (2016). *The World Bank Country Data*. Retrieved June 21, 2016, from <http://data.worldbank.org/country/malaysia>

Thi, N. B. D., Kumar, G. & Lin, C.Y. (2015). An Overview of Food Waste Management in Developing Countries: Current Status and Future Perspective. *Journal of*

Environmental Management, 157, 220–229. Retrieved from
<http://www.sciencedirect.com/science/article/pii/S0301479715300256>

Tuncer, B. & Schroeder, P. (2011). A Key Solution to Climate Change: Sustainable Consumption and Production. Making the Link (A. Eades, Ed.). Wuppertal, Germany: SWITCH-Asia Network Facility UNEP/Wuppertal Institute Collaborating Centre on Sustainable Consumption and Production (CSCP).

UNEP. (2010). Assessing the Environmental Impacts of Consumption and Production: Priority Products and Materials. Paris.

UNEP. (2015). Global Waste Management Outlook.

United Nations. (2015). Transforming Our World: The 2030 Agenda for Sustainable Development.

Warszawsky, D. N. (2015). The Devolution of Urban Food Waste Governance: Case Study of Food Rescue in Los Angeles. *Cities*, 49, 26–34. Retrieved from
<http://www.sciencedirect.com/science/article/pii/S0264275115000931>

WRAP. (2011). New Estimates for Household Food and Drink Waste in the UK A Report Presenting Updated Estimates of Food and Drink Waste from UK. Banbury.

WRAP. (2012). Helping Consumers Reduce Food Waste – A Retail Survey 2011. Banbury.

Wrigley, N. (2002). “Food Deserts” in British Cities: Policy Context and Research Priorities. *Urban Studies*, 39(11), 2029–2040.

Yin, R. K. (2009). *Case Study Research: Design and Methods*. California: SAGE Publications Inc.

Ying, N. C. & Karim, S. A. (2016). Historical and Contemporary Perspectives of the Nyonya Food Culture in Malaysia. *Journal of Ethnic Foods*, 1–14. Retrieved from
<http://www.sciencedirect.com/science/article/pii/S2352618116300427>

Zainon Noor, Z., Yusuf, R. O., Abba, A. H., Abu Hassan, M. A. & Mohd Din, M. F. (2013). An Overview for Energy Recovery from Municipal Solid Wastes (MSW) in Malaysia Scenario. *Renewable and Sustainable Energy Reviews*, 20, 378–384. Retrieved June 4, 2014, from
<http://linkinghub.elsevier.com/retrieve/pii/S1364032112006648>

Chapter 2: The Food Waste Hierarchy as a framework for the management of food surplus and food waste

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2.1 Abstract

The unprecedented scale of food waste in global food supply chains is attracting increasing attention due to its environmental, social and economic impacts. Drawing on interviews with food waste specialists, this study construes the boundaries between food surplus and food waste, avoidable and unavoidable food waste, and between waste prevention and waste management. This study suggests that the first step towards a more sustainable resolution of the food waste issue is to adopt a sustainable production and consumption approach and tackle food surplus and waste throughout the global food supply chain. The authors examine the factors that give rise to food waste throughout the food supply chain, and propose a framework to identify and prioritise the most appropriate options for prevention and management of food waste. The proposed framework interprets and applies the waste hierarchy in the context of food waste. It considers the three dimensions of sustainability (environmental, economic, and social), offering a more holistic approach in addressing food waste. Additionally, it considers the materiality and temporality of food. The Food Waste Hierarchy posits that prevention, through minimisation of food surplus and avoidable food waste, is the most attractive option. The second most attractive option involves the distribution of food surplus to groups affected by food poverty, followed by the option of converting food waste to animal feed. Although the proposed Food Waste Hierarchy requires a fundamental re-think of the current practices and systems in

place, it has the potential to deliver substantial environmental, social and economic benefits.

Key words: Food waste, food surplus, waste minimization, waste prevention, waste management, food poverty, waste hierarchy, sustainable consumption and production

2.2 Introduction

Appropriate waste management is recognised as an essential prerequisite for sustainable development (UNEP, 2011; UN Habitat, 2010). Historically, in urban contexts, public waste management focused on removing potentially harmful substances or materials away from human settlements (Wilson et al., 2012; Velis et al., 2009). As the environmental, social and financial implications of unsustainable use of raw materials and growing waste generation in the short and long term became apparent (The Government Office for Science, 2011b; Stern, 2006), waste management began to shift from a mere pollution prevention and control exercise, towards a more holistic approach.

Frameworks and concepts, such as the waste hierarchy (Figure 6), the '3Rs' (Reduce, Re-use, Recycle), extended producer responsibility, polluter pays principle (Engel et al., 2008), life cycle assessment and Sustainable Consumption and Production (SCP) (Pires et al., 2011), were introduced and the paradigm of 'sustainable resource management' was developed (Barton et al., 1996). Sustainable resource management is grounded on the notion that 'waste' can be a 'resource' (Bringezu and Bleischwitz, 2009). Restricting resource use to more sustainable levels and applying resource efficiency can effectively reduce Greenhouse Gas (GHG) emissions linked to climate change, as well as offer other benefits of economic and social nature (Barrett and Scott, 2012; Defra, 2011; WRAP, 2010).

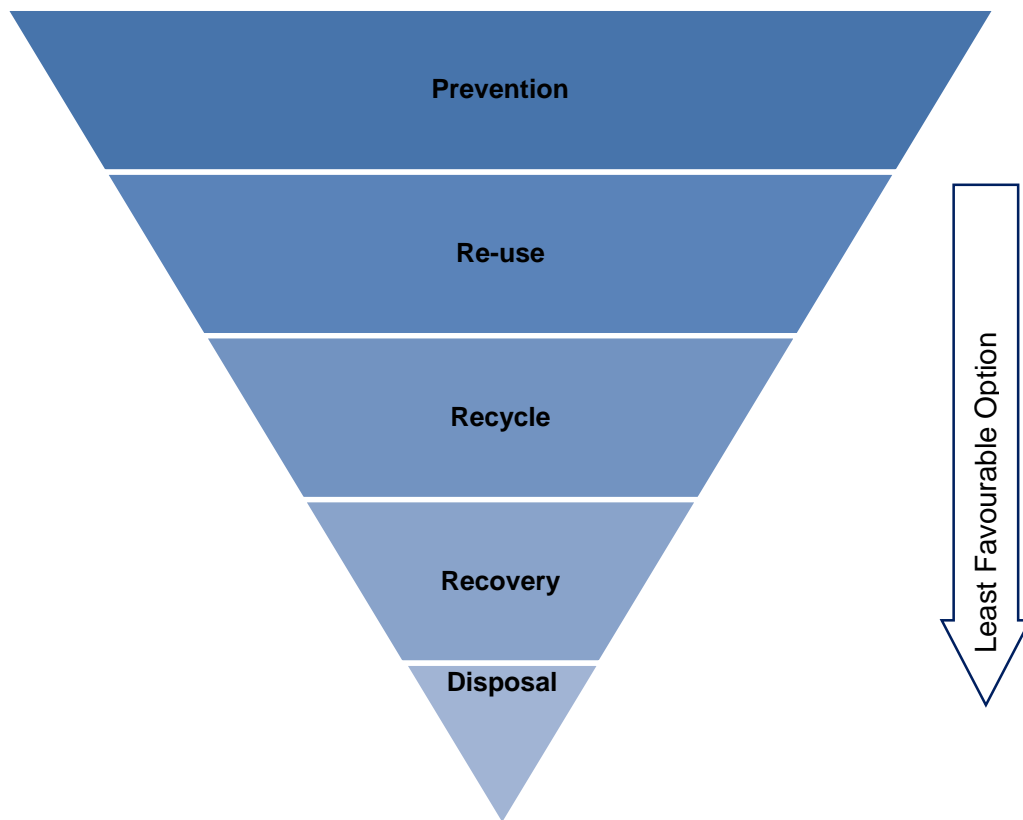


Figure 6: The waste hierarchy (European Parliament Council, 2008)

In the evolving waste management field, a waste stream receiving growing attention is food waste. As the scale of food waste's negative environmental, social and economic impacts are becoming more apparent, and global food security is becoming more pressing, food waste is increasingly recognised as being central to a more sustainable resolution of the global waste challenge (EPA, 2012; Defra, 2011; Government of South Australia, 2010). Recognising the significance of food waste, this study aims to address the following research question: 'how can food surplus and food waste be managed more sustainably?'

Building on the expertise of food waste specialists, the authors conducted a number of interviews that provide insights into the current practices, future trends, barriers and opportunities for more sustainable management of food surplus and food waste. The key themes that emerged from the interviews inform and shape the development of a comprehensive framework for the management of food surplus and waste throughout the Food Supply Chain (FSC) through the use of Grounded Theory (GT). This framework conceptualises food waste, and builds on this to interpret and apply the waste hierarchy in the context of food waste. The resulting Food Waste Hierarchy aims to act as a guide in establishing the most appropriate options for dealing with the mounting food waste challenge.

The remainder of this paper is structured as follows. Sections 2.3 and 2.4 provide the context by offering a brief overview of the scale of the food waste challenge, and relevant waste and sustainability concepts. Section 2.5 presents the methods employed for data collection and analysis. Section 2.6 provides a discussion on the findings of this study and proposes the food surplus and food waste framework. Finally, the conclusions of this research are presented in Section 2.7, along with the implications of the study.

2.3 The global food waste challenge

In response to concerns over escalating GHG emissions and other environmental impacts associated with food waste (Garnett and Wilkes, 2014), a growing number of national and regional policies identify food waste as a priority waste stream (EPA, 2012; Defra, 2011; Government of South Australia, 2010). Food security is an increasingly pressing global issue (The Government Office for Science, 2011a; UNEP, 2009; FAO, 1981) and it raises question about the amount of food wasted in the global FSC that could have otherwise been used to feed people (Stuart, 2009).

2.3.1 The global food supply chain: food losses and waste

Food is lost or wasted throughout the FSC, from the initial stage of agriculture to the final consumption stage (Parfitt et al., 2010; Smil, 2004). Figure 7 illustrates the stages in the FSC that give rise to food losses and waste.

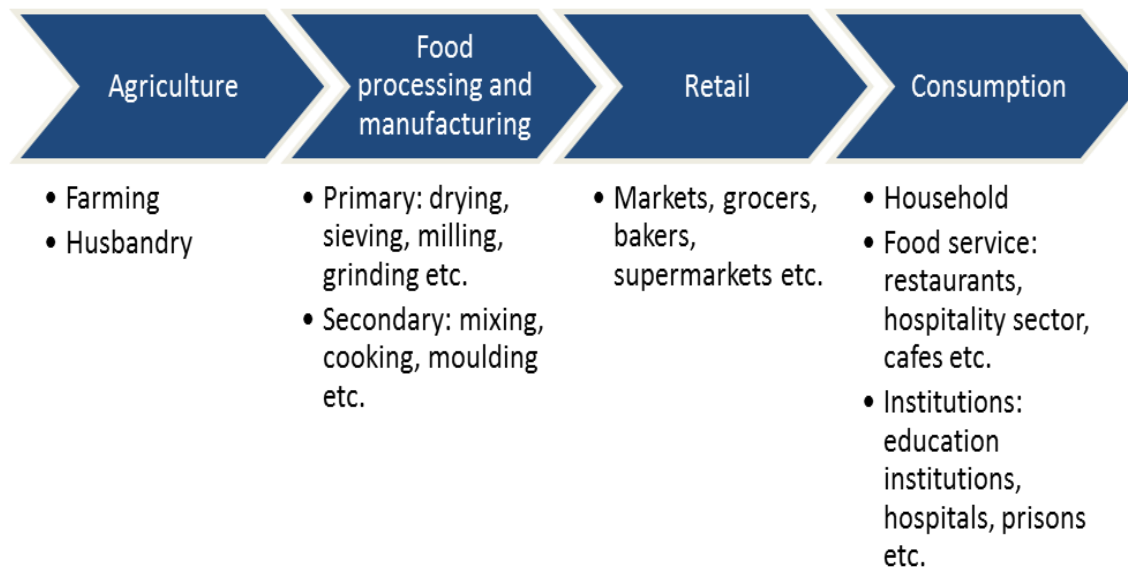


Figure 7: Activities giving rise to food losses and waste in the food supply chain (Parfitt et al., 2010; Smil, 2004; Lundqvist et al., 2008).

Three main definitions of food waste can be found in the literature. Firstly, The Food and Agriculture Organization (FAO) (1981) defines food waste as wholesome edible material intended for human consumption, arising at any point in the FSC that is

instead discarded, lost, degraded or consumed by pests. Secondly, Stuart (2009) adds to the FAO's definition, by stating that food waste should also include edible material that is intentionally fed to animals or is a by-product of food processing diverted away from the human food chain. Finally, Smil (2004) suggests that food waste covers the definitions above, but adds over-nutrition, the gap between the energy value of consumed food per capita and the energy value of food needed per capita. Stuart's definition provides a wider scope for food surplus and waste management opportunities, because it includes food losses due to animal feeding and the diversion of food processing by-products. For this reason and for the purpose of this study, Stuart's definition is adopted.

Food waste, or losses, refer to the decrease in edible food mass throughout the human FSC (Gustavsson et al., 2011). Food losses or spoilage take place at production, postharvest and processing stages in the FSC (Gustavsson et al., 2011; Grolleaud, 2002). At the final stages of the FSC such as during retail and final consumption, the term food waste is applied and generally relates closer to behavioural issues (The Government Office for Science, 2011b; Parfitt et al., 2010). Food losses/spoilage, conversely, relate more to systems that require investment in infrastructure. Table 3 presents examples of food waste and losses during different stages of the FSC.

Table 3: Examples of food waste and losses throughout the food supply chain (The Government Office for Science, 2011b; Parfitt et al., 2010).

Stage	Examples of food waste/loss
Harvesting - handling at harvest	Edible crops left in field, ploughed into soil, eaten by birds, rodents, timing of harvest not optimal: loss in food quality Crop damaged during harvesting/poor harvesting technique Out-grades at farm to improve quality of produce
Threshing	Loss through poor technique
Drying - transport and distribution	Poor transport infrastructure, loss owing to spoiling/bruising
Storage	Pests, disease, spillage, contamination, natural drying out of food

Stage	Examples of food waste/loss
Primary processing - cleaning, classification, de-hulling, pounding, grinding, packaging, soaking, winnowing, drying, sieving, milling	Process losses Contamination in process causing loss of quality
Secondary processing - mixing, cooking, frying, moulding, cutting extrusion	Process losses Contamination in process causing loss of quality
Product evaluation – quality control: standards recipes	Product discarded/out-grades in supply chain Destructive testing
Packaging - weighing, labelling, sealing	Inappropriate packaging damages produce Grain spillage from sacks attack by rodents
Marketing - publicity, selling, distribution	Damage during transport: spoilage Poor handling in wet market Losses caused by lack of cooling/cold storage
Post-consumer - over- or inappropriate purchasing, storage, preparation, portioning and cooking	Buying more than what is needed Plate scrapings and surplus food cooked and not used Poor storage/stock management in homes: discarded before serving Poor food preparation technique: edible food discarded with inedible Food discarded in packaging: confusion over 'best before' and 'use by' dates
End of life - disposal of food waste/ loss at different stages of supply chain	Food waste discarded may be separately treated, fed to livestock/poultry, mixed with other wastes and landfilled

Studies on the magnitude of food losses and waste, across the production and consumption stages of the FSC have been undertaken in developing and developed countries (Gustavsson et al., 2011; Parfitt et al., 2010; Smil, 2004). Such studies argue that there are major knowledge gaps in relation to global food losses and waste. According to Lundqvist et al (2008), as much as half of all food grown is lost or wasted before and after it reaches the consumer. Figure 8 illustrates the global food losses and waste throughout the FSC according to Smil (2000). 'From field to fork', postharvest losses are estimated at 2600 kcal per capita per day, which includes animal feed and waste in distribution and households. Stuart (2009) estimates that North America and

Europe discard 30 - 50% of their food supplies, enough to feed the world's hungry three times over. Gustavsson et al (2011) suggest that one third of the edible parts of food produced for human consumption gets lost or wasted through the global FSC, amounting to 1.3 billion tons per year.

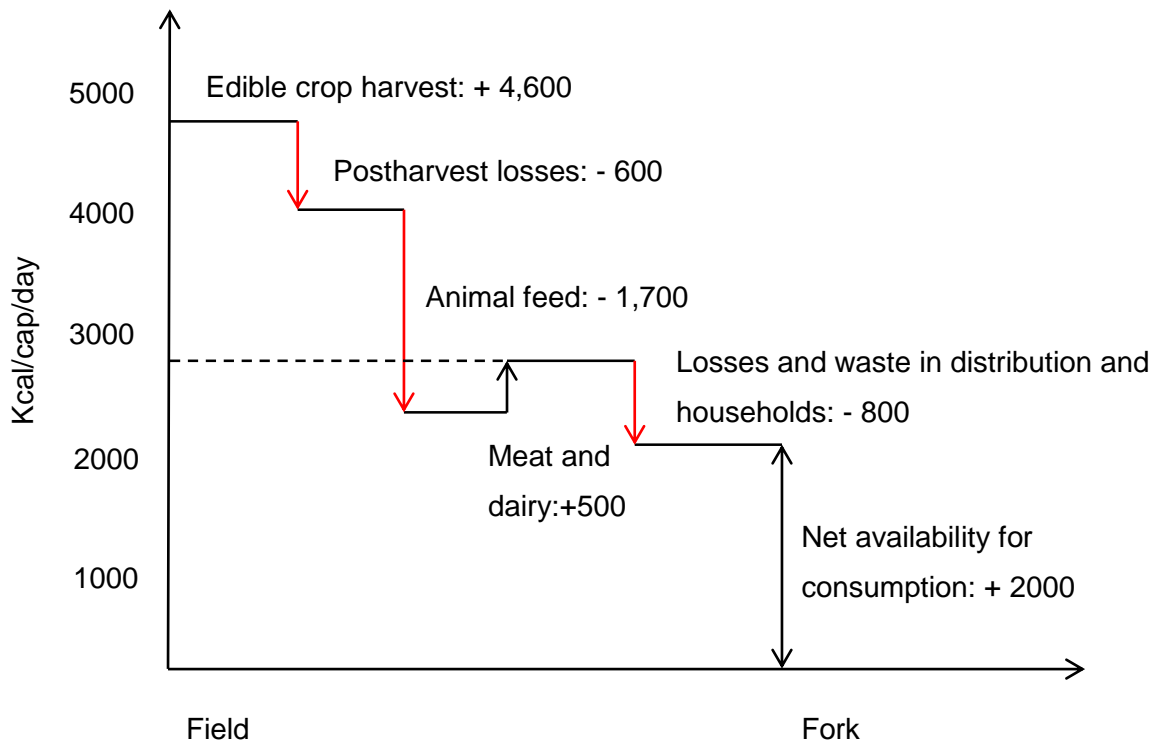


Figure 8: Amount of food produced at field level and estimates of the losses and wastage in the food supply chain (Lundqvist et al., 2008; Smil, 2000)

The distribution of food losses and waste varies between developed and developing countries, and between rich and poor producers and consumers (Gustavsson et al., 2011; Hodges et al., 2010; Lundqvist et al., 2008). Overall food losses and waste are higher in developed countries than those in developing countries, with an average of 280 - 300 kg per capita per year food loss in Europe and North America and an average of 120 - 170 kg per capita per year food loss in Sub-Saharan Africa and South and Southeast Asia. In developing countries, the majority of the food losses occur in the first stages of the FSC (Gustavsson et al., 2011). This is due to poor harvesting technologies, lack of transport and poor storage in combination with extreme climatic conditions. In developed countries food waste during the consumption stage accounts for over 40% of the total food losses and waste in the FSC (Gustavsson et al., 2011).

2.3.2 Economic, environmental and social implications of food waste

Food waste has substantial economic impact (Evans, 2011b; WRAP, 2011b; Morrissey and Browne, 2004). The economic cost of global food wastage in 2007 was estimated at USD 750 billion (FAO, 2013). Quested et al (2011) suggest that the food and drink

wasted in UK homes that could have been eaten has a retail value of approximately £12 billion. WRAP (2007) estimates that each household throws away between £4.80 and £7.70 of food that could have been eaten each week, which amounts to £250 - £400 a year or £15,000 -£24,000 in a lifetime. The Sustainable Restaurant Association (2010) states that food waste costs UK restaurants approximately 2-3% of their turnover.

Gustavsson et al (2011) and Lundqvist et al (2008) highlight the economic value of the food produced throughout the FSC. They suggest that avoidable food losses have a direct and negative impact on the income of both farmers and consumers. For the smallholders living on the margins of food insecurity, a reduction in food losses could have an immediate and significant impact on their livelihoods. For consumers affected by food poverty the priority is to have access to food products that are nutritious, safe and affordable. Food insecurity is often more a question of access related to purchasing power and prices of food, than a supply problem. Improving the efficiency of the FSC has the potential to bring down the cost of food to the consumer and thus increase access. Considering the magnitude of food losses in the FSC, making profitable investments in reducing losses could be one way of reducing the cost of food.

The US Environmental Protection Agency (EPA) (2012) highlights the economic implications of food waste and encourages food producers, retailers and the food service sector to reduce food waste in order to achieve substantial cost savings. These costs are not only linked to reduced purchasing costs, but also to the final waste disposal costs (EPA, 2003). UNEP (2011) places emphasis on the economic benefits of resource efficiency and waste reduction and suggests that minimisation of resource use, waste and other emissions have the potential to yield cost savings, identify new business fields, and increase employment and competitiveness.

One of the main environmental impacts of food waste is related to its final disposal in landfills. When food waste is disposed in landfills, methane and carbon dioxide are produced as part of its natural decomposition process. Methane and carbon dioxide are GHGs contributing to climate change, with methane being the more potent of the two, trapping 21 times more heat than carbon dioxide (Adhikari et al., 2006). It is estimated that the waste sector accounts for approximately 3% of global GHG emissions, with the same figure applicable for the UK (UNEP, 2010; Stern, 2006). Defra (2011) identifies food waste as a priority waste stream for action as it accounts for almost half of all CO₂ emissions associated with waste in the UK.

Another environmental impact of food waste is linked to the embedded carbon from the previous life cycle stages of food before it became waste. Activities associated with the production of food such as agriculture (including land use change), processing, manufacturing, transportation, storage, refrigeration, distribution and retail have an embedded GHG impact (Padfield et al., 2012; Tuncer and Schroeder, 2011; Lundqvist et al., 2008). Agriculture is associated with nearly 22% of all GHG emissions, with livestock production accounting for approximately 18% of total GHG emissions (Lundqvist et al., 2008; McMichael et al., 2007; Steinfeld et al., 2006).

Barrett and Scott (2012) analyse how the food sector is one area where significant reductions in GHG emissions are possible. They calculate that preventing food waste has the potential of a 456 million tons GHG emission reduction by year 2050 in the UK. WRAP (2011b) estimates that avoidable food waste led to 17 million tons of CO₂ eq. in 2010, equivalent to the emissions of 1 in 5 cars on UK roads. Within the European Union (EU), food, housing and transportation are the three sectors responsible for approximately 70% of overall environmental impact of human consumption and production (Tukker et al., 2010). Food products rank second in terms of highest production-cycle-wide resource use and environmental impact potential in Germany (Moll and Jose, 2006). It is estimated that the food sector is the cause of approximately 22% of the global warming potential in the EU (European Commission, 2006).

Other environmental impacts of food waste include natural resources depletion (such as soil nutrients, water and energy), the disruption of the biogenic cycles of nitrogen and phosphorus used in agriculture as fertilizers (Rockström et al., 2009; Smil, 2002) and the environmental pollution potential throughout the FSC but particularly during waste disposal (FAO, 2013; Lundqvist et al., 2008; Lundie and Peters, 2005).

In addition to environmental and economic impacts, food waste also has social implications (Salhofer et al., 2008). These tend to focus around the ethical and moral dimension of wasting food, in particular in relation to the inequality between on the one hand wasteful practices, and on the other food poverty (Evans, 2011a; Stuart, 2009; Wrigley, 2002). As the issue of global food security is becoming increasingly important in local and global agendas, the reduction of food losses and waste throughout the FSC, as well as alternative diets, are considered as a first step towards achieving food security (Haberl et al., 2011; Schönhart et al., 2009; Engström et al., 2004). Edwards and Mercer (2007) make mention of the 'ethics of food waste' and explore the emergence of 'freeganism' and 'gleaning' movements in Australia as an alternative to current consumption patterns. These groups consume food that has been thrown away to minimise their environmental impact and address social inequality in terms of food access (Edwards and Mercer, 2007). Gregson et al (2007) highlight the conflict

between the social values attached to 'thrift' and the environmental values that underpin reuse and the implications of this conflict for waste generation and prevention. Evans (2011b) discusses the link between frugality and sustainable consumption, arguing that frugality relates to being moderate or sparing in the use of money, goods and resources with particular emphasis on careful consumption and the avoidance of waste. Evans (2011b) suggests frugality has a strong moral dimension and is indeed linked to more sustainable forms of consumption. This is particularly true to food waste and the notion that wasting or diverting food away from human consumption is immoral (Parfitt et al., 2010). Gregson et al (2013) raise the significance of the social context in the transition of surplus, to excess and eventually to waste. Finally, Evans (2012) highlights the particular material culture of food waste that complicates and eventually prevents recirculation and recovery.

2.3.3 *The time dimension*

It is important to consider the dimension of time in the analysis of the food waste challenge and identify key parameters that will influence the scale and nature of the problem in the future (for a discussion on the time dimension of sustainability see Lozano, 2008). Two of these parameters are the growing world population and climate change. As the global population is rising, food waste generation is not diminishing and food security is becoming an increasingly urgent issue (Gustavsson et al., 2011; The Government Office for Science, 2011a; Lundqvist et al., 2008). In addition, while efforts to accurately predict the impact of climate change on crop yields and food production highlight uncertainties over future scenarios (Haberl et al., 2011), UNEP (2009) estimates that up to 25% of the world food production may become 'lost' during this century as a result of climate change, water scarcity, invasive pests and land degradation. As previously discussed, food losses and waste across the FSC contribute GHG emissions linked to climate change. With climate change becoming an increasingly critical challenge, it is anticipated that the environmental implications of food waste will come under more scrutiny (FAO, 2013).

Time is also an important consideration in the discussion about food waste due to food's material nature i.e. it decomposes with time thus becomes inedible and eventually waste. Unlike other waste materials such as glass, metals, paper and plastic, food's properties change within a relatively short amount of time. For this reason, the time dimension is crucial to the transition of food into food waste (for a discussion on the implications of food's materiality on the broader socio-temporal context of food practices see Evans, 2011c). As a consequence, food's materiality and temporality becomes central to the interpretation and application of the waste hierarchy within the context of food waste.

2.4 Concepts in waste management and sustainability

The waste hierarchy and the concept of sustainable consumption and production provide the theoretical foundation to this study. An overview of these concepts is provided in the section below.

2.4.1 The waste hierarchy

The principles behind the waste hierarchy were introduced into European policy as early as the 1970s, with the 1975 Directive on Waste (European Parliament Council, 1975) and the EU's Second Environment Action Program in 1977 (European Commission, 1977). The waste hierarchy was then clearly defined in European legislation in the Community Strategy for Waste Management in 1989 (European Parliament Council, 1989). Since then, the waste hierarchy has been adopted worldwide as the principal waste management framework. Other frameworks promoted by Japan and countries across Asia, such as the '3Rs', provide a similar approach to waste management by prioritising the options of reducing, reusing and recycling waste (Sakai et al., 2011; Shekdar, 2009; Yoshida et al., 2007).

The aim of the waste hierarchy is to identify the options most likely to deliver the best overall environmental outcome. As illustrated in Figure 6, the most favourable option is 'prevention', and at the bottom of the inverted pyramid, the least favourable option is 'disposal'. Although the European Waste Framework Directive (European Parliament Council, 2008) advises the Member States to consider the social and economic impacts as well as the environmental, the waste hierarchy, as a framework, primarily focuses on delivering the best environmental option. The focus of the waste hierarchy on the environmental over economic factors has been the basis of criticism from a number of economists urging for the waste hierarchy to be considered as a flexible guideline for formulating waste strategies (Rasmussen et al., 2005; Porter, 2002; Price and Joseph, 2000).

2.4.2 Sustainable production and consumption

The United Nations Environmental Program (2008) defines Sustainable Consumption and Production (SCP) as the "production and use of goods and services that respond to basic needs and bring a better quality of life, while minimising the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardise the needs of future generations". In this context, the SCP approach is seen as a practical implementation strategy to achieve sustainable development, encompassing the economy, society and environment with the use of both technological and social innovation.

SCP policies include strategies aiming to decouple economic growth from environmental degradation, meet basic human needs, and avert the rebound effect, a term used to describe the phenomenon where the negative impacts of growing consumption outweigh the benefits of efficiency and technological improvements (Barrett and Scott, 2012; Sorrell and Dimitropoulos, 2008; Greening et al., 2000). SCP is an integrated approach, targeting both the supply of and demand for goods and services, by reducing the adverse impacts of both their production and consumption (UNEP, 2008).

On the sustainable production side, some traditional examples include cleaner production, pollution prevention, eco-efficiency and green productivity, although often the term 'cleaner production' is used as an umbrella term for all the sustainable production activities (Almeida et al., 2013). On the consumption side, SCP connects the consumer with the product and the producer, allowing more sustainable choices to be made (Tukker et al., 2010). Some traditional examples include eco-labelling, sustainable procurement, supply chain management, waste minimisation, recycling and resource efficiency measures (Tukker et al., 2010). However, one of the fundamental principles of SCP is the integration of sustainable production concerning the supply side, and sustainable consumption referring to the demand side of human economic activities (Tuncer and Schroeder, 2011). SCP embraces 'life-cycle thinking' in order to avoid problem shifting from one life-cycle stage to another, one geographical area to another and one environmental medium to another (Clark, 2007).

Waste is often incorrectly considered as an issue that is more prominent in the consumption stage of a product's life (Tuncer and Schroeder, 2011). In reality, waste is generated throughout all the stages of production and consumption (UNEP, 2008). In line with SCP, sustainable resource and waste management is relevant to the whole life cycle of products and services. This study follows this approach, and applies it to the food supply chain.

2.5 Methods

The authors conducted a number of interviews with food waste specialists that informed and shaped the development of the proposed framework for the management of food surplus and waste throughout the food supply chain. Seven group interviews were conducted with 23 food waste specialists. The group interviews were conducted with individuals from the following organisations: the Department for Environment, Food and Rural Affairs (Defra), the Waste and Resource Action Program (WRAP), Fareshare, Brook Lyndhurst, the Sustainable Restaurant Association (SRA), Harper Adams University College and SKM Enviro. The organisations were selected to

represent different food waste stakeholders, such as government bodies, private companies, non-governmental and not-for-profit organisations. The selected organisations focus on different elements of food surplus and waste management, including policy development and delivery, strategy implementation, food waste treatment operation, research, food poverty reduction, engineering and consultancy. Table 4 presents a brief profile of the interviewed organisations.

Table 4: Interviewed organisations' profile

Organisation	Role
Defra	Responsible for producing the waste strategy for England and Wales
WRAP	Responsible for delivering Defra's waste policy
Fareshare	UK charity that redistributes food surplus to groups affected by food poverty
Brook Lyndhurst	Research and strategy consultancy
Sustainable Restaurant Association	'Not-for-profit' membership organisation that assist restaurants in becoming more sustainable
Harper Adams University College	Agricultural university that treats organic waste with an on-campus anaerobic digestion plant
SKM Enviros	Environmental engineering consultancy

UK based organisations were selected for the interviews due to the UK's strong commitment and focus on addressing food waste, and the recent evidence of food waste prevention (WRAP, 2011b). The latest estimates suggest that the UK food waste household generation was reduced by approximately 13% in the period between 2006/07 and 2009/10 (WRAP, 2011b). Although a number of different factors are likely to have contributed to the observed decrease of food waste generation at the household, this figure is nonetheless a commendable result towards food waste prevention. In addition, England managed to increase the average household waste recycling rate from 10% in the year 2000/01, to 40% in year 2010/11 (Defra, 2011).

2.5.1 Data collection

The interviews were a combination of semi-structured and in depth interviews. This interview format provided a degree of structure in order to cover specific key questions, but equally, offered flexibility by allowing the introduction of new questions (Saunders

et al., 2009). The group interviews provided insight into the current practices, future trends, barriers and opportunities for more sustainable management of food surplus and waste. An interview framework was prepared in advance to provide a general guide to the discussions, including:

- i. Brief organisation profile and role of individuals within it
- ii. Current role and practices of organisation, in relation to food surplus and waste
- iii. Motivation and drivers for more sustainable management of food surplus and waste
- iv. Barriers and constraints to more sustainable management of food surplus and waste
- v. Opportunities and suggestions for more sustainable management of food surplus and waste

2.5.2 *Data analysis*

The qualitative data collected during the interviews were analysed through a series of analytical processes linked to the grounded theory research approach (for more information on grounded theory see Saunders et al., 2009; Jupp, 2006; Glaser and Strauss, 1967a). Initially the data collected in the form of interview notes were classified into meaningful categories partially derived from the interview framework and from the data themselves. This process revealed three key themes, namely the distinction between food surplus and food waste, between avoidable and unavoidable waste, and finally between waste prevention and waste management. Following this emergent patterns and relationships amongst the key themes were identified through the processes of reduction and rearranging of the data into more manageable and comprehensible forms. Once the relationships between food surplus and food waste, and between avoidable and unavoidable waste were mapped, the options for prevention and management were identified and prioritised according to the principles of the waste hierarchy. Finally, the key themes, the relationships between them and the prioritised options for prevention and management, were synthesised and presented in the food surplus and waste framework discussed below.

2.5.3 *Limitations*

This study proposes a framework for addressing the food waste challenge. The proposed options and the prioritisation of these options were derived based primarily on the environmental and social aspects of food surplus and waste, when comparing options like for like. Whether the most favourable options are financially more advantageous than the least favourable options, and whether there is only one answer to this question, can be argued. A cost benefit analysis of the options in the proposed

framework is outside the scope of this study, however such an exercise would be useful in validating this framework in real life, specific scenarios. As with any framework, it intends to act as a guide in the decision making process and not provide a 'one solution fits all' approach. This paper draws on expertise and experiences from Europe, in particular the UK. Contributions from other parts of the world would complement this study and increase its generalisability. Threats to reliability and validity of the research findings, such as subject error and bias, and observer error and bias were minimised by carefully formulating the research design (Saunders et al., 2009).

2.6 Findings and discussion

The findings of the study are presented below. The discussion is structured under the three main themes that emerged from the interviews; namely the boundaries between food surplus and food waste, avoidable and unavoidable food waste, waste prevention and waste management.

2.6.1 Food surplus, food security and waste

The first theme that emerged from the interviews relates to the issues of food surplus, food security and waste, and the relationships between them. During the interviews it became apparent that the distinction between the terms 'food surplus' and 'food waste' is essential to a more sustainable approach to addressing food waste. Often food surplus is incorrectly referred to as food waste, missing the subtle difference between the two terms, as Fareshare points out. However, food surplus is food produced beyond our nutritional needs, and waste is a product of food surplus. Interviewees from Brook Lyndhurst advise that up to a point, food surplus acts as a safeguard against unpredictable weather patterns affecting crops. However, as interviewees from WRAP highlight, the current scale of global food surplus is in fact threatening, not safeguarding, global food security. Comparing the average daily nutritional needs per person against the actual food available at the retail level in high- income countries highlights the growing gap between food production and consumption.

This argument is prominent in the literature, where agronomists suggest that a food supply of 130% over our nutritional needs should guarantee food security (Smil, 2004; Bender and Smith, 1997). The actual daily food requirements are rarely above 2000 kcal per person per day. Applying an increase of 130%, an approximate 2600 kcal per person per day food supply should be sufficient to cover daily nutritional needs and ensure food security (Lundqvist et al., 2008; Smil, 2004; Bender and Smith, 1997). However, according to FAO's (2010) food balance sheets, retail in high income countries now make available over 3000 kcal of food per person per day. The figure for the USA exceeds 3800 kcal per person per day and the EU mean is 3500 kcal per

person per day (Smil, 2004). Comparing the food made available with the actual food requirements (covering nutritional needs and a buffer for food security) reveals the extent of undesirable food surplus of over 1000 kcal per person per day in some high-income countries.

According to Fareshare, inequalities in access to the global FSC exist not only between affluent and poorer countries, but also within individual countries. The number of people affected by food poverty is increasing even within the most affluent countries in the world, especially during the current economic recession. The disparity between food waste on one hand and food poverty on the other, draws attention to the social and ethical implications of food waste. Therefore, making the distinction between the 'desired' food surpluses acting as a safeguard of food security, the undesired excessive food surplus and food waste, is particularly relevant when considering the options available to combat food waste.

2.6.2 Avoidable and unavoidable food waste

An important distinction in the process of developing a sustainable framework for addressing food waste is the one between 'avoidable' and 'unavoidable' food waste. This distinction provides insight into the degree to which food waste prevention is feasible or not, thus it is pivotal in the formulation of strategies for food waste minimisation, as Brook Lyndhurst and Defra suggest.

WRAP defines avoidable food waste as food thrown away because it is no longer wanted or has been allowed to go past its best. The vast majority of avoidable food is composed of material that was, at some point prior to disposal, edible, even though a proportion is not edible at the time of disposal due to deterioration (e.g. gone mouldy).

Avoidable food waste includes foods or parts of food that are considered edible by the vast majority of people. Unavoidable food waste is described as waste arising from food that is not, and has not been, edible under normal circumstances. This includes parts of foods such as fruit skin, apple cores and meat bones. Although this classification provides insight into the degree to which food waste prevention is feasible (i.e. there will always be an amount of food waste produced that is unavoidable) it can be subjective, as WRAP explains. What is considered edible by 'a majority of people' depends on a number of factors, such as culture in the form of shared values and common practices, religious beliefs, social norms and personal preferences.

The Brook Lyndhurst, Defra and WRAP interviewees stress the significance of the distinction between avoidable and unavoidable food waste, as it reveals how

unnecessary food waste is and emphasises the substantial potential for food waste prevention.

2.6.3 Waste prevention and waste management

The third theme that emerged from this study involves the distinction between the terms 'waste prevention' and 'waste management'. There are occasions when the waste hierarchy is wrongly referred to as the waste management hierarchy, interviewees from Defra point out. This misconception originates from the fact that the hierarchy was initially developed as a tool designed to assist in identifying the most appropriate solution once waste has been generated.

Waste prevention includes activities that avoid waste generation, for instance, reduction of food surplus, whereas waste management includes the options available to deal with food waste once it has been generated, such as composting and anaerobic digestion, SKM Enviro explains.

The SRA explains how first they provide practical advice to restaurants on methods to avoid food waste generation as a priority, and then suggest more sustainable ways to manage the remaining food waste.

Defra's policy on food waste makes the distinction between waste prevention and management clear, although, as the interviewees from Book Lyndhurst add, waste prevention is a lot more challenging to achieve.

As the concepts of sustainable resource management, life cycle management and sustainable consumption and production alter the way 'waste' is perceived, the divide between waste prevention and waste management becomes more apparent.

2.6.4 Food surplus and waste framework

The three themes that emerged from this study informed the proposed food waste framework presented in Figure 9. The proposed framework interprets and applies the waste hierarchy in the context of food waste, provides and prioritises options for dealing with food surplus, avoidable and unavoidable food waste. The most favourable options are presented first and are placed at the top of the framework, with the least favourable options presented lower down the framework. The prioritisation of the options for dealing with food surplus and food waste is based on the waste hierarchy. The framework is summarised into the Food Waste Hierarchy presented in Figure 10.

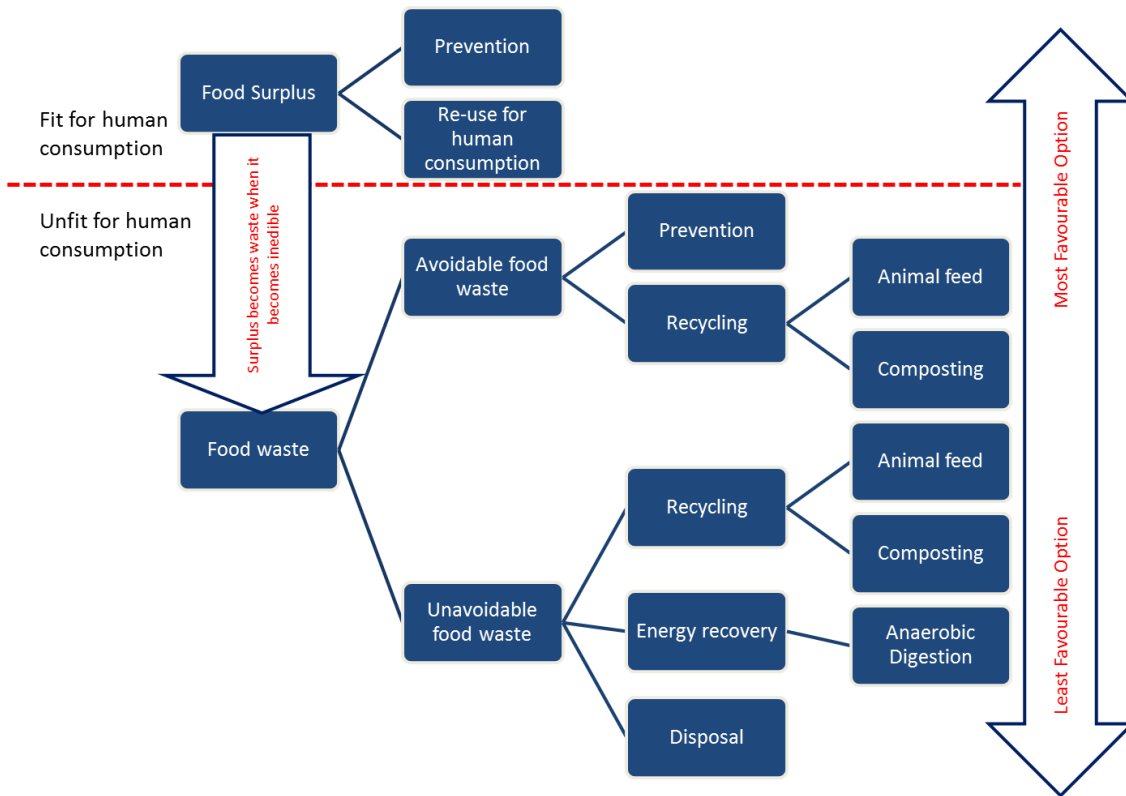


Figure 9: Food surplus and waste framework

Starting from the issue of the undesirable food surplus, the priority is to prevent overproduction and oversupply of food beyond human nutritional needs at all the stages of the FSC. In agriculture and food production, this includes production of only the necessary amount of food to cover global nutritional needs and safeguard food security. In retail and the consumption stages, such as the food service sector and households, food surplus prevention includes the supply of only what is required, correct portion sizing and addressing unsustainable consumption patterns. For the surplus food that has not been consumed, the option of redistributing it to groups affected by food poverty is proposed; assuming food safety can be ensured.

As illustrated in Figure 9, the instant food surplus becomes unfit for human consumption it becomes food waste. At that point, the distinction between avoidable and unavoidable food waste becomes central in the decision making process for the most appropriate waste management options. The greatest potential for prevention of avoidable food waste in developing countries lies in the earlier stages of the FSC where the majority of the food losses are observed. This includes improved agricultural infrastructure, technological skills and knowledge, more efficient storage, transport and distribution techniques. Food waste prevention in developed countries should focus more on the retail and consumption stages such as the food service sector and consumers. A shift to more sustainable consumption patterns and practices, and

increased awareness of food waste's impact on the environment, have the potential to reduce generation of avoidable food waste. Other methods of preventing avoidable food waste include improved food labelling, better consumer planning when shopping and preparing food, as well as technological improvements in packaging and improving shelf life for perishable foods. Once the options for prevention are exhausted (as far as practicably feasible), it is proposed for avoidable food waste to be recycled into animal feed, and via composting as a secondary option, when recycling into animal feed is not feasible. Once recycling efforts are exhausted, treatment of food waste with energy recovery, such as with anaerobic digestion, is the next preferred option. Finally, disposal in landfill is the least favourable option for managing the remaining fraction of unavoidable food waste once all the other options are exhausted. Finally, the proposed food surplus and waste framework is summarised into the Food Waste Hierarchy presented in Figure 10.

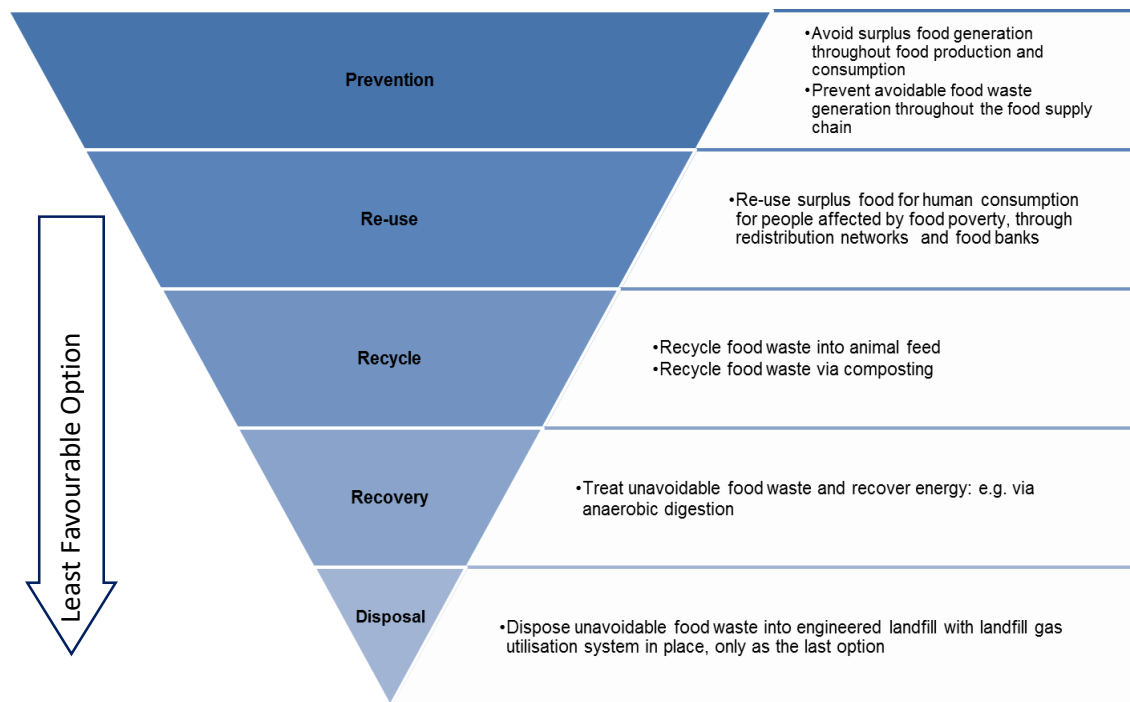


Figure 10: The Food Waste Hierarchy

2.7 Conclusion

Food waste is becoming an increasingly important issue at both a local and global level. The GHG emissions from food production and consumption, as well as from its final disposal, depletion of natural resources and pollution are the most prominent environmental impacts associated with food waste. Food waste has economic implications for everyone within the food supply chain, from the farmer to the food producer and the consumer. These include food production and purchasing costs, as

well as costs associated with the final disposal of food waste. In the context of a fast growing world population and diminishing natural resources, the disparity between food poverty and food wastage raises concerns over global food security and highlights the social and moral dimensions of food waste.

Considering the environmental, economic, social implications of food waste through time, this study suggests that the first step towards a more sustainable resolution of the growing food waste issue is to adopt a sustainable production and consumption approach and tackle food surplus and waste throughout the entirety of the global food supply chain, as opposed to focusing only on the consumption stage. The distinction between food surplus and food waste on one hand, and avoidable and unavoidable food waste on the other, are crucial in the process of identifying the most appropriate options for addressing the food waste challenge.

By applying the waste hierarchy in the context of food, this study proposes the Food Waste Hierarchy as a framework to identify and prioritise the options for the minimisation and management of food surplus and waste throughout the food supply chain. The resulting Food Waste Hierarchy considers the three dimensions of sustainability (environmental, economic, and social), offering a more holistic approach in addressing the food waste issue. Additionally, the Food Waste Hierarchy takes into account the materiality and temporality of food and encompasses the dimension of time in the discussion. Prevention, in the form of food surplus and avoidable food waste reduction, features as the most advantageous option within the Food Waste Hierarchy. Although prevention requires a fundamental re-think of the current practices and systems in place, it has the potential to deliver substantial environmental, social and economic benefits.

The proposed Food Waste Hierarchy aims to challenge the current waste management approach to food waste, contribute to the debate about waste management and food security, and influence the current academic thinking and policies on waste and food to support more sustainable and holistic solutions. The authors hope that the Food Waste Hierarchy is relevant to policy makers, waste producers throughout the food supply chain, as well as researchers. In the case of minimising food waste produced in the household, interventions should tackle both the individual practices of consumers, and the material and social context within which food waste is generated. Preventing food waste in agriculture and food processing requires improved infrastructure and technological solutions in harvesting, storage, transport and distribution, supported by large-scale investment and local policies. Additionally, the issue of food waste should be considered earlier within the food supply chain to capture and maximise the waste prevention opportunities. Waste management policies should be integrated and aligned

with the wider policies on food, agriculture, food standards, food poverty alleviation and sustainable production and consumption. Finally, further research is required to provide the evidence base to support this shift to a more sustainable food surplus and waste management and to inform policy implementation.

2.8 References

- Adhikari, B. K., Barrington, S. & Martinez, J. (2006). Predicted Growth of World Urban Food Waste and Methane Production. *Waste Management & Research*, 24(5), 421–433. Retrieved March 13, 2012, from <http://wmr.sagepub.com/cgi/doi/10.1177/0734242X06067767>
- Almeida, C. M. V. B., Bonilla, S. H., Giannetti, B. F. & Huisingh, D. (2013). Cleaner Production Initiatives and Challenges for a Sustainable World: An Introduction to This Special Volume. *Journal of Cleaner Production*, 47, 1–10. Retrieved August 15, 2013, from <http://linkinghub.elsevier.com/retrieve/pii/S0959652613001443>
- Barrett, J. & Scott, K. (2012). Link between Climate Change Mitigation and Resource Efficiency: A UK Case Study. *Global Environmental Change*, 22(1), 299–307. Retrieved May 16, 2012, from <http://linkinghub.elsevier.com/retrieve/pii/S0959378011001907>
- Barton, J. R., Dalley, D. & Patel, V. S. (1996). Life Cycle Assessment for Waste Management. *Waste Management*, 16, 35–50.
- Bender, W. & Smith, M. (1997). Population, Food, and Nutrition. *Population Bulletin*, 51(4), 2–46.
- Bringezu, S. & Bleischwitz, R. (2009). *Sustainable Resource Management: Global Trends, Visions and Policies* (S. Bringezu and R. Bleischwitz, Eds.). Sheffield: Greenleaf Publishing.
- Clark, G. (2007). Evolution of the Global Sustainable Consumption and Production Policy and the United Nations Environment Programme's (UNEP) Supporting Activities. *Journal of Cleaner Production*, 15(6), 492–498. Retrieved June 28, 2012, from <http://linkinghub.elsevier.com/retrieve/pii/S0959652606001739>
- Defra. (2011). *Government Review of Waste Policy in England 2011*. London.
- Edwards, F. & Mercer, D. (2007). Gleaning from Gluttony: An Australian Youth Subculture Confronts the Ethics of Waste. *Australian Geographer*, 38(3), 279–296. Retrieved July 4, 2012, from <http://www.tandfonline.com/doi/abs/10.1080/00049180701639174>
- Engel, S., Pagiola, S. & Wunder, S. (2008). *Designing Payments for Environmental*

Services in Theory and Practice: An Overview of the Issues. *Ecological Economics*, 65(4), 663–674. Retrieved February 29, 2012, from <http://linkinghub.elsevier.com/retrieve/pii/S0921800908001420>

Engström, R., Carlsson-Kanyama, A., Engströma, R. & Carlsson-Kanyamab, A. (2004). Food Losses in Food Service Institutions Examples from Sweden. *Food Policy*, 29(3), 203–213. Retrieved April 3, 2012, from <http://linkinghub.elsevier.com/retrieve/pii/S030691920400020X>

EPA. (2003). *Beyond RCRA Waste and Materials Management in the Year 2020*. Washington DC. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/22441629>

EPA. (2012). *Putting Surplus Food To Good Use*. Washington DC.

European Commission. (1977). *2nd Environmental Action Programme 1977-1981* (OJ C 139, 13.6.77). Brussels.

European Commission. (2006). *Environmental Impact of Products (EIPRO)*. Spain.

European Parliament Council. (1975). *Council Directive of 15 July 1975 on Waste* 75/442/EEC. Brussels.

European Parliament Council. (1989). *A Community Strategy for Waste Management*, SEC/89/934. Brussels.

European Parliament Council. (2008). *Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 Concerning Integrated Pollution Prevention and Control*. Brussels.

Evans, D. (2011a). *Blaming the Consumer – Once Again: The Social and Material Contexts of Everyday Food Waste Practices in Some English Households*. *Critical Public Health*, 21(4), 429–440.

Evans, D. (2011b). *Thrifty, Green or Frugal: Reflections on Sustainable Consumption in a Changing Economic Climate*. *Geoforum*, 42(5), 550–557. Retrieved March 14, 2012, from <http://linkinghub.elsevier.com/retrieve/pii/S0016718511000443>

Evans, D. (2011c). *Beyond the Throwaway Society: Ordinary Domestic Practice and a Sociological Approach to Household Food Waste*. *Sociology*, 46(1), 41–56. Retrieved March 10, 2012, from <http://soc.sagepub.com/cgi/doi/10.1177/0038038511416150>

Evans, D. (2012). *Binning, Gifting and Recovery: The Conduits of Disposal in Household Food Consumption*. *Environment and Planning D: Society and Space*, 30(6), 1123–1137. Retrieved January 30, 2014, from <http://www.envplan.com/abstract.cgi?id=d22210>

- FAO. (1981). Food Loss Prevention in Perishable Crops. Rome: Food and Agricultural Service Bulletin, no. 43, FAO Statistics Division.
- FAO. (2010). Dietary Energy Consumption.
- FAO. (2013). Food Wastage Footprint. Impacts on Natural Resources. Rome.
- Garnett, T. & Wilkes, A. (2014). Appetite for Change. Social, Economic and Environmental Transformations in China's Food System. Oxford. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/24622803>
- Glaser, B. & Strauss, A. (1967). The Discovery of Grounded Theory. Chicago: Aldine.
- Government of South Australia. (2010). Valuing Our Food Waste. South Australia's Household Food Waste Recycling Pilot. Adelaide.
- Greening, L. A., Greene, D. L. & Difiglio, C. (2000). Energy Efficiency and Consumption - the Rebound Effect - a Survey. *Energy Policy*, 28, 389–401.
- Gregson, N., Crang, M., Laws, J., Fleetwood, T. & Holmes, H. (2013). Moving up the Waste Hierarchy: Car Boot Sales, Reuse Exchange and the Challenges of Consumer Culture to Waste Prevention. *Resources, Conservation and Recycling*, 77, 97–107. Retrieved January 30, 2014, from <http://linkinghub.elsevier.com/retrieve/pii/S0921344913001353>
- Gregson, N., Metcalfe, A. & Crewe, L. (2007). Identity, Mobility, and the Throwaway Society. *Environment and Planning D: Society and Space*, 25(4), 682–700. Retrieved January 30, 2014, from <http://www.envplan.com/abstract.cgi?id=d418t>
- Grolleaud, M. (2002). Post-Harvest Losses: Discovering the Full Story. Overview of the Phenomenon of Losses during the Post-Harvest System. Rome: FAO, Agro Industries and Post-Harvest Management Service.
- Gustavsson, J., Cederberg, C., Sonesson, U., Otterdijk, R. van & Meybeck, A. (2011). Global Food Losses and Food Waste. Extent, Causes and Prevention. Rome.
- Haberl, H., Erb, K.-H., Krausmann, F., Bondeau, A., Lauk, C., Müller, C., et al. (2011). Global Bioenergy Potentials from Agricultural Land in 2050: Sensitivity to Climate Change, Diets and Yields. *Biomass & bioenergy*, 35(12), 4753–4769. Retrieved August 14, 2013, from <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3236288&tool=pmcentrez&rendertype=abstract>
- Hodges, R. J., Buzby, J. C. & Bennett, B. (2010). Postharvest Losses and Waste in Developed and Less Developed Countries: Opportunities to Improve Resource Use. *The Journal of Agricultural Science*, 149(S1), 37–45. Retrieved March 13,

2012, from http://www.journals.cambridge.org/abstract_S0021859610000936

Jupp, V. (2006). *The SAGE Dictionary of Social Research Methods* (V. Jupp, Ed.). London: SAGE Publications Ltd.

Lozano, R. (2008). Envisioning Sustainability Three-Dimensionally. *Journal of Cleaner Production*, 16(17), 1838–1846. Retrieved March 8, 2012, from <http://linkinghub.elsevier.com/retrieve/pii/S0959652608000401>

Lundie, S. & Peters, G. M. (2005). Life Cycle Assessment of Food Waste Management Options. *Journal of Cleaner Production*, 13(3), 275–286. Retrieved March 17, 2012, from <http://linkinghub.elsevier.com/retrieve/pii/S0959652604000952>

Lundqvist, J., Fraiture, C. de & Molden., D. (2008). *Saving Water: From Field to Fork Curbing Losses and Wastage in the Food Chain*. Stockholm.

McMichael, A. J., Powles, J. W., Butler, C. D. & Uauy, R. (2007). Food, Livestock Production, Energy, Climate Change, and Health. *The Lancet*, 370(9594), 1253–1263.

Moll, S. & Jose, A. (2006). Environmental Implications of Resource Use. *Journal of Industrial Ecology*, 10(3), 25–40.

Morrissey, J. & Browne, J. (2004). Waste Management Models and Their Application to Sustainable Waste Management. *Waste management*, 24(3), 297–308. Retrieved March 12, 2012, from <http://www.ncbi.nlm.nih.gov/pubmed/15016418>

Padfield, R., Papargyropoulou, E. & Preece, C. (2012). A Preliminary Assessment of Greenhouse Gas Emission Trends in the Production and Consumption of Food in Malaysia. *International Journal of Technology*, 3(1), 56–66.

Parfitt, J., Barthel, M. & Macnaughton, S. (2010). Food Waste within Food Supply Chains: Quantification and Potential for Change to 2050. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, 365(1554), 3065–81. Retrieved March 9, 2012, from <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2935112&tool=pmcentrez&rendertype=abstract>

Pires, A., Martinho, G. & Chang, N. (2011). Solid Waste Management in European Countries: A Review of Systems Analysis Techniques. *Journal of Environmental Management*, 92(4), 1033–1050. Retrieved from <http://dx.doi.org/10.1016/j.jenvman.2010.11.024>

Porter, R. C. (2002). *The Economics of Waste*. Washington DC: Resources for the Future.

- Price, J. L. & Joseph, J. B. (2000). Demand Management _A Basis for Waste Policy: A Critical Review of the Applicability of the Waste Hierarchy in Terms of Achieving Sustainable Waste Management. *Sustainable Development*, 8, 96–105.
- Quasted, T. E., Parry, D., Easteal, S. & Swannell, R. (2011). Food and Drink Waste from Households in the UK. *Nutrition Bulletin*, 36(4), 460–467. Retrieved July 3, 2012, from <http://doi.wiley.com/10.1111/j.1467-3010.2011.01924.x>
- Rasmussen, C., Vigsø, D., Ackerman, F., Porter, R., Pearce, D., Dijkgraaf, E., et al. (2005). *Rethinking the Waste Hierarchy*. Copenhagen: Environmental Assessment Institute.
- Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin Iii, F. S., Lambin, E. F., et al. (2009). A Safe Operating Space for Humanity. *Nature*, 461, 472–475.
- Sakai, S., Yoshida, H., Hirai, Y., Asari, M., Takigami, H., Takahashi, S., et al. (2011). International Comparative Study of 3R and Waste Management Policy Developments. *Journal of Material Cycles and Waste Management*, 13(2), 86–102. Retrieved March 22, 2012, from <http://www.springerlink.com/index/10.1007/s10163-011-0009-x>
- Salhofer, S., Obersteiner, G., Schneider, F. & Lebersorger, S. (2008). Potentials for the Prevention of Municipal Solid Waste. *Waste management*, 28(2), 245–59. Retrieved April 4, 2012, from <http://www.ncbi.nlm.nih.gov/pubmed/17442562>
- Saunders, M., Lewis, P. & Thornhill, A. (2009). *Research Methods for Business Students*. Harlow: Pearson Education Ltd.
- Schönhart, M., Penker, M. & Schmid, E. (2009). Sustainable Local Food Production and Consumption Challenges for Implementation and Research. *Outlook on Agriculture*, 38(2), 175–182.
- Shekdar, A. V. (2009). Sustainable Solid Waste Management: An Integrated Approach for Asian Countries. *Waste management*, 29(4), 1438–48. Retrieved May 23, 2012, from <http://www.ncbi.nlm.nih.gov/pubmed/19081236>
- Smil, V. (2000). *Feeding the World: Challenge for the 21st Century*. Cambridge, MA: The MIT Press.
- Smil, V. (2002). Nitrogen and Food Production: Proteins for Human Diets. *Ambio: A Journal of the Human Environment*, 31(2), 126–131.
- Smil, V. (2004). Improving Efficiency and Reducing Waste in Our Food System. *Environmental Sciences*, 1(1), 17–26.
- Sorrell, S. & Dimitropoulos, J. (2008). The Rebound Effect: Microeconomic Definitions,

Limitations and Extensions. *Ecological Economics*, 65(3), 636–649. Retrieved March 13, 2012, from <http://linkinghub.elsevier.com/retrieve/pii/S0921800907004405>

- Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. & De Haan, C. (2006). *Livestock's Long Shadow: Environmental Issues and Options*. Rome: FAO Publishing.
- Stern, N. (2006). *Stern Review: The Economics of Climate Change*. London: HM Treasury.
- Stuart, T. (2009). *Waste. Uncovering the Global Food Scandal*. London: Penguin.
- Sustainable Restaurant Association. (2010). *Too Good to Waste. Restaurant Food Waste Survey Report*. London.
- The Government Office for Science. (2011a). *Foresight Project on Global Food and Farming Futures Synthesis Report C7: Reducing Waste*. London.
- The Government Office for Science. (2011b). *Foresight. The Future of Food and Farming: Challenges and Choices for Global Sustainability*. London.
- Tukker, A., Cohen, M. J., Hubacek, K. & Mont, O. (2010). The Impacts of Household Consumption and Options for Change. *Journal of Industrial Ecology*, 14(1), 13–30. Retrieved August 12, 2013, from <http://doi.wiley.com/10.1111/j.1530-9290.2009.00208.x>
- Tuncer, B. & Schroeder, P. (2011). *A Key Solution to Climate Change: Sustainable Consumption and Production. Making the Link* (A. Eades, Ed.). Wuppertal, Germany: SWITCH-Asia Network Facility UNEP/Wuppertal Institute Collaborating Centre on Sustainable Consumption and Production (CSCP).
- UNEP. (2008). *Planning for Change. Guidelines for National Programmes*. Paris.
- UNEP. (2009). *The Environmental Food Crisis-The Environment's Role in Averting Future Food Crises* (C. Nellemann, M. MacDevette, T. Manders, B. Eickhout, B. Svihus, A. G. Prins, et al., Eds.). Norway: UNEP.
- UNEP. (2010). *Assessing the Environmental Impacts of Consumption and Production: Priority Products and Materials*. Paris.
- UNEP. (2011). *Decoupling Natural Resource Use and Environmental Impacts from Economic Growth*. Paris: United Nations Environment Programme.
- UNHSP. (2010). *Solid Waste Management in the World's Cities*. London.
- Velis, C., Wilson, D. C. & Cheeseman, C. (2009). 19th Century London Dust-Yards: A Case Study in Closed-Loop Resource Efficiency. *Waste management*, 29(4),

1282–90. Retrieved June 18, 2012, from
<http://www.ncbi.nlm.nih.gov/pubmed/19121575>

Wilson, D. C., Rodic, L., Scheinberg, A., Velis, C. & Alabaster, G. (2012). Comparative Analysis of Solid Waste Management in 20 Cities. *Waste Management & Research*, 30(3), 237–54. Retrieved April 9, 2012, from
<http://www.ncbi.nlm.nih.gov/pubmed/22407700>

WRAP. (2007). *Understanding Consumer Food Management Behaviour*. Banbury.

WRAP. (2010). *Securing the Future – The Role of Resource Efficiency*. Banbury.

WRAP. (2011). *New Estimates for Household Food and Drink Waste in the UK A Report Presenting Updated Estimates of Food and Drink Waste from UK*. Banbury.

Wrigley, N. (2002). “Food Deserts” in British Cities: Policy Context and Research Priorities. *Urban Studies*, 39(11), 2029–2040.

Yoshida, H., Shimamura, K. & Aizawa, H. (2007). 3R Strategies for the Establishment of an International Sound Material-Cycle Society. *Journal of Material Cycles and Waste Management*, 9(2), 101–111. Retrieved April 23, 2012, from
<http://www.springerlink.com/index/10.1007/s10163-007-0177-x>

Chapter 3: Conceptual framework for the study of food waste generation and prevention in the hospitality sector

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3.1 Abstract

Food waste has significant detrimental economic, environmental and social impacts. The magnitude and complexity of the global food waste problem has brought it to the forefront of the environmental agenda; however, there has been little research on the patterns and drivers of food waste generation, especially outside the household. This is partially due to weaknesses in the methodological approaches used to understand such a complex problem. This paper proposes a novel conceptual framework to identify and explain the patterns and drivers of food waste generation in the hospitality sector, with the aim of identifying food waste prevention measures. This conceptual framework integrates data collection and analysis methods from ethnography and grounded theory, complemented with concepts and tools from industrial ecology for the analysis of quantitative data. A case study of food waste generation at a hotel restaurant in Malaysia is used as an example to illustrate how this conceptual framework can be applied. The conceptual framework links the biophysical and economic flows of food provisioning and waste generation, with the social and cultural practices associated with food preparation and consumption. The case study demonstrates that food waste is intrinsically linked to the way we provision and consume food, the material and socio-cultural context of food consumption and food waste generation. Food provisioning, food consumption and food waste generation should be studied together in order to fully understand how, where and most importantly why food waste is generated. This

understanding will then enable to draw detailed, case specific food waste prevention plans addressing the material and socio-economic aspects of food waste generation.

Key words: Food waste, hospitality sector, social practices, food provisioning, food consumption, behaviour, material flow, eco-efficiency

3.2 Introduction

Food waste has become increasingly visible in policy and academic debates, due to its detrimental environmental, social and economic impacts (Gustavsson et al., 2011); however, evidence on the drivers that give rise to food waste throughout the food supply chain is still limited (Betz et al., 2015). Research tends to focus on household and retail food waste, in order to inform national and local waste management policy (Parizeau et al., 2015; WRAP, 2013). Emerging literature covering entire food supply chains (Beretta et al., 2013; Mena et al., 2014), the hospitality sector (Pirani and Arafat, 2015), and canteens in workplaces (Goggins and Rau, 2015) provides insights into the somewhat neglected topic of food waste generation outside the household. These gaps in literature exist because the significance of food waste has been recognised only recently, and due to the way food waste has been approached in research (Garrone et al., 2014). Food waste has been studied largely from an engineering, technological perspective, with the exception of a small but growing number of researchers from other disciplines (Cohen, 2015; Evans, 2014; Papargyropoulou et al., 2014; Edwards and Mercer, 2007). In addition, food waste has predominately been studied either through quantitative (see Beretta et al. 2013) or qualitative (see Evans, 2011) methods; however, there have been limited peer-reviewed papers using mixed methods.

Given the knowledge gap in food waste patterns and drivers outside the household and the limitations of existing methodological approaches, this paper proposes a mixed methods conceptual framework for the study of food waste generation and prevention. The framework is aimed at providing measures for food waste prevention in the hospitality sector, based on a comprehensive assessment of the context, drivers and patterns of food waste generation. The paper also presents a comprehensive case study of food waste generation in the hospitality sector, as a means to illustrate this conceptual framework. The case study demonstrates how the proposed conceptual framework can provide a deeper level of analysis and offers substantial empirical data on food waste generation.

The paper is structured as follows. Section 3.3 presents the background, origins and applications of the tools, methods and research strategies incorporated in the proposed conceptual framework and how the framework was developed. Section 3.4 explains how these tools, methods and research strategies have been applied within the

framework. In Section 3.5 a case study of food waste generation in a hotel restaurant in Malaysia is used as an example to illustrate how the proposed conceptual framework can be applied in a real research setting. The discussion on how the results from the case study relate to the literature on food waste generation is also presented in Section 3.5. Finally, the conclusions and the implications of the paper are presented in Section 3.6.

3.3 Literature review

This section provides a brief review to the main components of the proposed conceptual framework, with a focus on their origins and applications. It begins with tools and concepts used to collect and analyse quantitative data such as waste audit, Material Flow Analysis (MFA) and eco-efficiency analysis. Next, the section introduces the background to more qualitative research designs such as ethnography and grounded theory, and qualitative methods such as participant observation, interviews and focus groups. The section concludes with the development of the proposed conceptual framework, emerging from the literature.

The first quantitative method discussed in this section is the waste audit. Waste audits are used in baseline studies to assess hotspots of food waste generation and inform waste prevention and management strategies (WRAP, 2011c). They measure the quantity and composition of waste streams with the use of weighing scales and in-situ compositional analyses. Often waste audits are carried out for small samples that represent a larger population since they are time and labour intensive. They are often repeated at different times to account for seasonal or other time related variations. In research, waste audits are mainly applied in descriptive, baseline waste characterisation studies (Okazaki et al., 2008; Wilkie et al., 2015). Waste studies rely heavily on quantitative data (Newenhouse and Schmit, 2000), which can be analysed with the use of tools and methods from the field of industrial ecology, such as Material Flow Analysis (MFA) and eco-efficiency analysis. MFA is a systematic assessment of the flows and stocks of materials within a system defined in space and time (Brunner and Rechberger, 2004) MFA connects the sources, the pathways, and the intermediate and final sinks of a material. MFA aims to model a socioeconomic system, identify its ecologically and economically relevant flows of energy, materials and chemical substances (Fischer-Kowalski and Huttler, 1999). MFA is often described using the metaphor that the material fluxes represent the metabolism of the system (metabolism of the anthroposphere (Baccini and Brunner, 1991) and industrial metabolism (Ayres, 1989). The first applications of MFA were within the fields of economics and engineering, although MFA has been increasingly recognised as a useful decision making tool in resource, environmental and waste management (Deutz and Ioppolo,

2015; Rieckhof et al., 2014). MFA has been used in recent studies to quantify food losses in Switzerland (Beretta et al., 2013) and investigate food waste in the Swiss food service sector (Betz et al., 2015) Sankey diagrams can help to illustrate the MAF (Schmidt, 2008). A Sankey diagram is a graphic illustration of flows, like energy, material or money flows. The flows are depicted as arrows with the width of the arrows proportional to the size of the flow.

In addition to MFA, eco-efficiency is another concept from industrial ecology used in environmental and sustainability research (Gabriel and Braune, 2005). According to the World Business Council for Sustainable Development (WBCSD, 2000) eco-efficiency is concerned with creating more value with less impact. Eco-efficiency as an instrument for sustainability analysis, indicates an empirical relation in economic activities between environmental cost or value and environmental impact (Huppel and Ishikawa, 2005). Eco-efficiency can be expressed by the ratio of economic value/environmental impact (WBCSD, 2000). Eco-efficiency is improved by reducing the environmental impact while maintaining or increasing the economic value. Although the concept of eco-efficiency has been applied predominately at a product level, as a tool it has been used for example to promote the competitiveness of economic activities in a Finnish region and mitigate their harmful environmental impacts (Seppälä et al., 2005) and to evaluate waste management options in China (Zhao et al., 2011). In the waste management field it has been a useful tool in comparing competing waste management options (Pires et al., 2011). Despite their strengths, eco-efficiency analysis and MFA do not allow for the analysis of social practices, motivations and behaviours of waste producers. A number of methods can be used to analyse such phenomena, such as ethnography and Grounded Theory (GT).

Ethnography is the systematic study of people and cultures, rooted in the social sciences used extensively in anthropology and sociology (Gobo, 2008a). Such studies are conducted on a system bounded in space and time and embedded in a particular physical and sociocultural context (Emerson et al., 2001). In ethnography, the researcher spends a considerable amount of time carrying out field work in order to participate in the social life of the actors observed, while at the same time maintaining sufficient cognitive distance so that he or she can remain objective (Emerson et al., 2001). Various data collection methods are available in ethnography, including participant observations, interviews, focus groups, audio-visual material and documents (Gobo, 2008b). A number of waste and food waste studies have used an ethnographic approach (Evans, 2014; Goonan et al., 2014; Gregson et al., 2013; Hetherington, 2004). In these studies, a mixture of data collection methods was used such as interviews, focus groups and participant observation.

Participant observation is a qualitative method that involves the systematic observation, recording, analysis and interpretation of peoples' behaviour (Saunders et al., 2009). A certain level of immersion of the researcher in the research setting itself is required, in order to discover the material and social context in which the study is set within (Delbridge and Kirkpatrick, 1994). Gill and Johnson (2002) suggest four roles the researcher can adopt in participant observation: (i) complete participant; (ii) complete observer; (iii) observer as participant; and (iv) participant as observer. One of the advantages of participant observation is that it provides a form of triangulation for the other research methods adopted within the research design (Saunders et al., 2009). Along with participant observation, interviews have been commonly used in ethnographic studies (Sherman Heyl, 2001). Interviews can range from the highly structured as used in questionnaire surveys, through to the semi-structured, and the relatively unstructured (Crang and Cook, 2007b). Focus group is another method used to gain a rich understanding of a subject's views on a specific topic within a group (Saunders et al., 2009). The power dynamics within the group, the group's homogeneity, duration and location are factors affecting the outcome of the method (Crang and Cook, 2007a). In the field of sustainability, structured interviews and questionnaire surveys are the most popular type of interviews used, when assessing for example the drivers for corporate sustainability (Lozano, 2013), priorities for tropical peatland conservation (Padfield et al., 2015), patterns and drivers of household waste prevention (Quested et al., 2013; Quested et al., 2011), and household energy consumption (Sahakian and Steinberger, 2011). A number of studies (Padfield, 2011; Quested et al., 2011; Martin et al., 2006) follow up surveys with focus groups or group interviews to test the surveys' findings. Data collected by ethnographic methods described above have been in the past analysed with the use of grounded theory.

In GT, the researcher uses multiple stages of collecting, refining, and categorizing the data (Charmaz, 2014). The principles of emergence, theoretical sampling, and constant comparison are fundamental in GT in order to obtain a theory grounded in the data (Corbin and Strauss, 2008; Walsh et al., 2015). The principle of emergence requires that the researcher approaches the subject of research with as few predetermined ideas as possible and remains open to what is discovered empirically. This is achieved through the processes of theoretical sampling and constant comparison (Glaser and Strauss, 1967b). Theoretical sampling is the process in which the researcher simultaneously collects, codes, and analyses data, with the purpose of generating and developing theoretical ideas. In this process the researcher makes decisions about the type of data worthwhile collecting and analysing in order to develop aspects of the emerging theory (Glaser, 1978). Through the constant comparative method data are continuously compared with previously collected and analysed data as the researcher

determines if the new data support (or not) the emerging concepts. GT has been used mainly in sociology, nursing, management, education, marketing and the information systems field (Bryant and Charmaz, 2007). In the waste management field (Gai et al., 2009) used GT to analyse data from interviews about medical waste management in China. The coding procedures of GT were used in a number of studies to understand the drivers for householders to minimise waste (Graham-Rowe et al., 2014) and commuters' motivation to use a car (Gardner and Abraham, 2007). In most of these cases GT was used as a method of analysis of qualitative data, not with the intention of deriving new theories.

3.3.1 Definitions of food waste

The FAO (2014) defines food waste as food which was originally produced for human consumption but was not consumed by humans, instead it was directed into a non-food use (for humans), feed for animals or waste disposal (e.g. feedstock to an anaerobic digestion plant or incinerator, disposal at a landfill). Based on Quested et al (2011) and Papargyropoulou et al (2014) food waste is grouped into three categories: (i) Avoidable food waste refers to food that could have been eaten at some point prior to being thrown away, even though much of it would have been inedible at the point of disposal. (ii) Unavoidable food waste refers to the fraction of food that is not usually eaten, including items such as banana skins, apple cores, egg shells and chicken bones. (iii) Possibly avoidable food waste refers to food that is eaten in some situations but not others, such as potato skins. In the context of a high-end restaurant, such as the case study presented in this paper, possibly avoidable and unavoidable are combined and reported as unavoidable food waste. This is justified as it is unlikely that possibly avoidable food waste items will be consumed in a restaurant like that (for example most likely potato skins will not be served to the customer).

3.3.2 Developing a conceptual framework for the study of food waste generation and prevention.

The conceptual framework for the study of food waste generation and prevention presented in this paper was developed from the literature (based on Betz et al., 2015; Graham-Rowe et al., 2014; Evans et al., 2013; Evans, 2011; Quested et al., 2011) (Figure 11). It was designed so it can respond to the challenges faced in the research process and adapt to the individual nature of a particular case study. In the initial stages of the development of the conceptual framework, a waste audit featured as the main tool for data collection, focusing primarily on quantitative data such as weight, composition and origin of food waste; however, the waste audit offered limited insights into the drivers for food waste generation. Building from ethnography, methods such as participant observation, interviews and focus groups were incorporated in order to

collect qualitative data. The framework is designed in such a way that both quantitative and qualitative methods are carried out simultaneously and the emerging findings inform the direction and focus of both methods. For example, a preliminary analysis of the waste audit data can indicate which stages of the food preparation and consumption the qualitative methods should focus more on, and what questions would yield deeper insights during the interviews and focus group. In a similar way, insights on the drivers of food waste generation arising from the qualitative methods can inform the type of quantitative data needed to prove or disprove the main points coming out of the interviews. This exchange of findings and results between the different methods, illustrated by the use of dotted red arrows in Figure 11, is designed to happen concurrently to the actual data collection and analysis process. Figure 11 suggests a linear process flow; in reality the research process involved a number of cycles of simultaneous data collection and analysis, before reaching a conclusion.

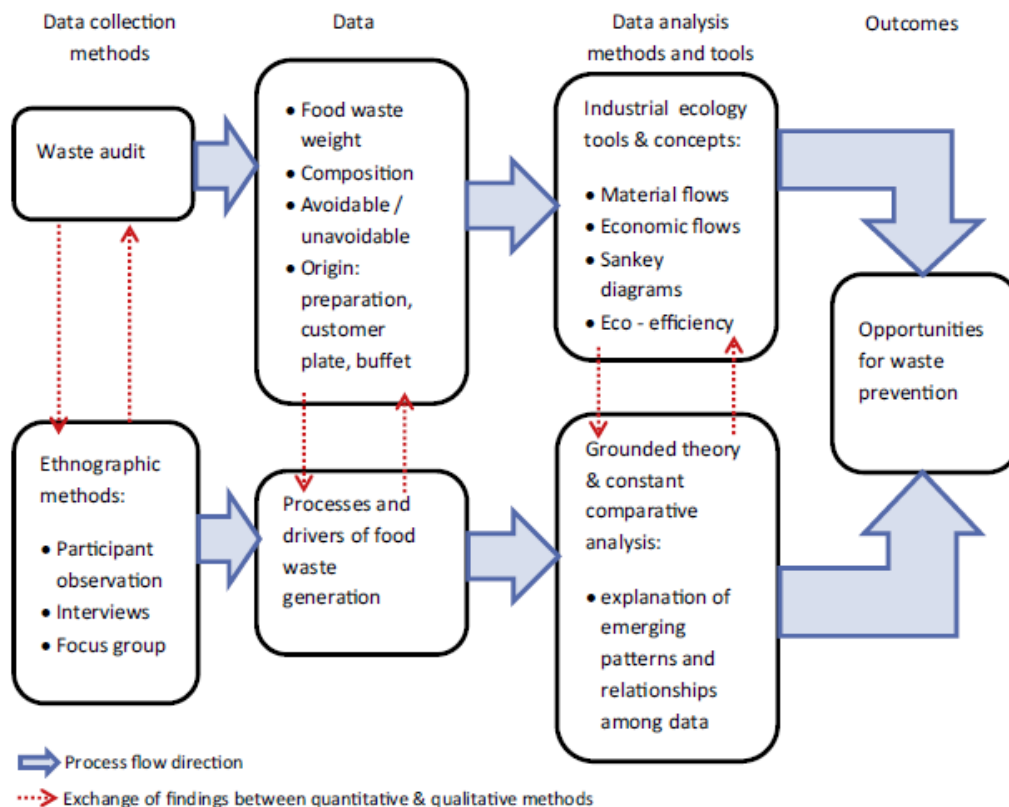


Figure 11: Conceptual framework for the study of food waste generation and prevention in the hospitality sector

3.4 Methods

The conceptual framework for the study of food waste generation and prevention was implemented and tested in a case study. The unit of analysis for the case study was a hotel restaurant. The case study used in-depth and semi-structured interviews, focus

groups, observation, and quantitative data collection techniques. Food waste generation was studied from the time of purchasing of raw food supplies, throughout food storage, preparation and cooking, consumption and, finally, discarding of food waste. An in-depth analysis of waste collection and final disposal was not included, since these stages are outside the remit and control of the restaurant.

3.4.1 Quantitative methods and tools from industrial ecology

The quantitative data collection methods used in the case study were aimed at identifying processes and activities within the restaurant that give rise to food waste. They assessed the amount and type of food purchased and measured the food waste generated in order to prioritise the most promising measures for waste prevention. By measuring how much food waste was produced from the different processes within the restaurant, the most wasteful processes could be identified. This evidence guided the waste minimisation strategy by informing where the focus should be and which measures could have a greater impact in reducing food waste.

The quantitative data collection methods comprised of a food waste audit, photographic records, collection of financial records, and inventory of food purchases. During the food waste audit, the amount and type of food waste were identified (Quested et al., 2011). The amount of food waste generated was measured and recorded continuously throughout the day for one week in order to account for weekly variations.

Building on previous research (Sustainable Restaurant Association, 2010), three types of food waste were recorded: 'Preparation waste': produced during the food preparation stage, due to overproduction, peeling, cutting, expiration, spoilage, over cooking, etc.; 'Customer plate leftover waste': food discarded by customers after the food has been sold or served to them; and 'Buffet leftover waste', such as excess food that has been prepared but has not been taken onto the customer's plate or consumed thus left on the buffet or a food storage area (in the chiller or warmer) and later discarded. In addition to the amount of food waste generated and the process that gave rise to it, in-situ estimates of the edible fraction of food waste were made based on visual observations; so that the avoidable and unavoidable fractions could be determined. Visual examination was selected due to time restrictions, although this method may be subjective. In order to reduce error and bias, visual observations were carried out and cross checked by two researchers. The reasons that led to the wastage were also recorded.

These three types of food waste were recorded and linked to a specific type of meal (breakfast, lunch, or dinner). This allowed conclusions to be drawn about the most wasteful eating times and the food types that contributed most to the wastage.

Significant efforts were made into capturing food waste at the point of generation and recording not only its total weight but also the weight of its individual ingredients before they were mixed with the rest of the food waste; however, in the case of oils a combination of weighing and estimation based on visual observations was used because it was not always possible to separate the oil from the cooked meals. This approach provided sufficient information in order to categorise food and food waste into nine food commodity groups, including oils, and produce detailed material flow diagrams. The food commodity categories are presented in Table 5.

Table 5: Food commodity groups used in this study to categorise incoming food and waste (Gustavsson et al., 2011)

Food commodity category	Type of foods included in category
Cereal	Rice, pasta, noodles, bread, flour, pastries, other wheat, barley, maize, oat products
Dairy	Milk, cheese, yogurt, ice cream and other dairy products
Eggs	Eggs
Fish and seafood	Fresh water fish, demersal fish, pelagic fish, other marine fish, crustaceans, other aquatic animals, and plants
Fruits	All fruits
Meat	Bovine meat, mutton/goat meat, pig meat, poultry meat, other meat, offal
Oils and fats	Olive, palm, vegetable oils, butter, other animal and vegetable oils and fats
Sauces including liquid fraction of dishes	All premade and in situ prepared sauces, including tinned tomatoes, salad dressing, canned soup, and all other liquid fractions within dishes
Vegetables, roots and pulses	All vegetables, potatoes and pulses

The weight and composition of the food waste was then combined with the incoming flows of food to produce economic flows graphs and eco-efficiency ratios for each food commodity group. The incoming flows of the fresh food delivered and cooked daily, such as fruits, vegetables, meat, fish, were determined by the food purchasing and delivery records of the waste audit week. For food items used from the stock, such as oils, rice, pasta, canned foods, the average weight used in a week was extrapolated by the food purchasing inventory records of the previous 12 months. Using two different ways to calculate the weight of incoming food and outgoing waste is a limitation of the method. In order to overcome this limitation, the extrapolated figures were verified by the chefs as an accurate reflection of the amount used within a week.

The material and economic flows were illustrated with the use of Sankey flow diagrams. Sankey flow diagrams were used to visualise the magnitude of economic

and material flows taking place within the case study. The thickness of each link in the diagrams represented the amount of flow from a source to a target node, in this occasion from food provisioning to food consumption. In order to calculate the eco-efficiency of the different food commodities, the cost parameter was matched with the environmental parameter, in this case waste generation (WBCSD, 2000). The cost parameter was expressed in Ringgit Malaysia² (RM)/kg of food, and the environmental parameter as percentage of food wasted. The eco-efficiency ratios were plotted in a graph with the y axis representing the food cost and the x axis the percentage of food wasted. The graph was then divided into four quarters representing high, medium and low eco-efficiencies. For example, a food item of high cost and high waste would be plotted on the top right quarter of the graph and have a low eco-efficiency, whereas a food item of low cost and low waste would be plotted at the bottom left quarter and have a high eco-efficiency. The classification of high, medium or low eco-efficiency was done comparatively to other food items, instead of absolute terms.

3.4.2 Ethnographic and qualitative methods: interviews, participant observation and focus groups

Two types of interviews were carried out in this study: in-depth structured and informal non-structured. In-depth interviews of sixteen employees from the case study restaurant and three representatives of the National Solid Waste Management Department were carried out in order to understand the broader context in which food waste generation occurred in the hospitality sector. Following the initial round of in-depth interviews, participant observation combined with informal non-structured interviews with the restaurant employees were carried out while collecting quantitative data. The observations were recorded through field notes in the form of a diary (Evans, 2011).

A focus group was also carried out following some preliminary data analysis. The main patterns emerging from the data were discussed in the focus group comprising seven members of the management, procurement, sales, finance, food preparation and operations teams of the restaurant. The focus group was conducted in English, since it is the common language used among the restaurant staff of various nationalities. The focus group allowed further analysis and verification of the data collected through the other methods and opportunity to seek clarification on behaviour recorded during the

² 1 RM = 0.23 USD on 02/09/2015 (XE Currency Converter, 2015)

participant observation. It offered further insights as to where, how, why food waste was produced, and what could be done to prevent it.

3.4.3 Grounded theory and the constant comparative analysis method

The conceptual framework for studying food waste generation and prevention was based on an inductive and iterative process in which theory was built and modified from the data collected. The constant comparative analysis method from grounded theory was applied by continually comparing sections of the data, to allow categories to emerge and for relationships between these categories to become apparent (Glaser and Strauss, 1967b). The emerging categories were then modified into more abstract concepts. Theory was built by organising these concepts into logical frames. As new data emerged, new concepts were added until a point of 'saturation' was reached whereby new data no longer contributed anything new. The theory that was developed through this process explained how, why and where food waste was produced and finally helped to identify the most promising measures for food waste prevention.

3.5 Results and discussion

The case study of a restaurant operating within a five-star international hotel in Kuala Lumpur, Malaysia was used as an example to demonstrate how the proposed conceptual framework can be applied in a real research setting. The hotel consisted of 118 guest rooms and suites, spa and gym facilities, meeting and banquet facilities. The restaurant was selected as it provided full access for data collection, offered a mixture of cuisines and food service types (combination of buffet style and 'a la carte') for all three main meal times (breakfast, lunch, dinner) and catered for a variety of customers. The restaurant offered an opportunity to test how factors such as type of cuisine, food service style, meal times and customers, affected food waste generation.

The case study focused on the main restaurant of the hotel and the six kitchens/food preparation areas linked to it, serving food to an average of 172 customers per day. Breakfast was in the form of a buffet and catered primarily for the hotel guests, although walk-in customers were also accepted. Lunch was in the form of a buffet between Monday and Saturday, and 'a la carte' every Sunday. Dinner was in the form of 'a la carte' with the exception of Saturdays when special buffet events were organised. The restaurant's operating hours were 6.30 am – 11.00 pm, Monday to Sunday. At the time of the study all waste from the hotel including food waste was being sent to landfill. Interviews with the National Solid Waste Management Department revealed that there were plans to introduce a separate food waste collection scheme and divert food waste from landfill into an anaerobic digestion plant.

3.5.1 *Food waste generation patterns and drivers*

On average 173 kg of food waste per day was generated by the restaurant's operations (see Table 6). As described in the methods section, food waste was divided into preparation waste, buffet leftover and customer plate leftover waste.

The amount of food waste per customer decreased with the number of customers served per day, due to economies of scale. Some variation in this pattern can be explained by the fact that part of the food preparation (and subsequently generation of preparation food waste) occurred on the day before, not on the actual day of a given event (e.g. on Tuesday some preparation was made for Wednesday's buffet, which had the highest number of customers). This showed that the restaurant operations may be most efficient when it is operating at close to full capacity.

The highest daily food waste generation per customer was recorded (1.70 kg per customer) on Sunday. On Sunday preparation waste per customer was the second highest recorded that week (0.8 kg per customer), in particular during lunch and dinner times when 'a la carte' service was offered (as opposed to buffet service). This showed that 'a la carte' service produced more preparation waste per customer compared to buffet service. In addition, customer plate waste during lunch time was the highest recorded that week (1.37 kg per customer). Observation of food consumption practices and informal discussions with staff revealed that on Sunday only one family of seven tourists on vacation in Malaysia had 'a la carte' lunch. According to the waiter on duty that day, the leader of the family ordered food above what was required for seven people:

Waiter: "He ordered too much, you know for only seven people, 3 pizzas, 7 portions of nasi (rice), 3 whole chickens, starters, salads, bread, too much..."

Researcher: "Did you tell him it was too much? Did you advise him on the portion sizes?"

Waiter: "Yes, of course, but you know with customers you can't insist too much, they are the customers. Also in some cultures the man has to provide for his family, his wives and children, and show he can buy more than they need. This guy ordered 7 desserts afterwards and half of the food on the table was not even touched. It's not right you know, but we can't do anything about that."

Table 6: Daily food waste generation in a week

	Fri 02/05/14	Sat 03/05/14	Sun 04/05/14	Mon 05/05/14	Tue 06/05/14	Wed 07/05/14	Thu 08/05/14	Daily averag e	Stand. deviatio n
Customers served per day	101.0	168.0	89.0	161.0	148.0	295.0	243.0	172.1	74.0
Preparation waste (kg)	62.5	78.1	72.5	101.5	138.7	136.2	78.0	95.4	31.1
Buffet leftover(kg)	40.6	54.6	22.0	13.3	44.7	41.4	34.1	35.8	14.1
Customer plate leftover (kg)	16.4	46.6	54.6	31.3	34.5	47.3	49.9	40.1	13.4
Total food waste (kg)	118.5	179.3	149.1	160.6	217.9	224.9	162.0	173.2	37.8
Food waste per customer (kg/person)	1.2	1.1	1.7	1.0	1.5	0.8	0.7	1.1	0.4

Table 7: Average food waste generation per customer served.

	Breakfast buffet	Lunch 'a la carte'	Lunch Buffet	Dinner 'a la carte'	Dinner buffet
Preparation waste per customer (kg/person)	0.6	0.8	0.6	0.6	0.5
Customer plate leftover waste per customer (kg/person)	0.3	1.4	0.1	0.3	0.4
Buffet leftover waste per customer (kg/person)	0.3	NA	0.4	NA	0.2
Total waste per customer (kg/person)	1.2	2.2	1.1	1.0	1.0

This is an example of many encountered in the study, where the customer's cultural beliefs were given as the reasons behind consumption practices (wasteful or otherwise). This example illustrated that food consumption practices have a direct impact on food waste generation patterns. In addition, it showed the anxiety food waste causes (for anxiety associated with food wasting in the household see Evans, 2011), in this case not even to the waste producer but to the waiter feeling uncomfortable with the wasteful practices of the customer.

The average food waste generation per customer served is shown in Table 7. These figures can serve as a benchmark for food waste generation, regardless whether many or only a few customers were served at a particular time. The results suggested that the lunch time 'a la carte' meal had the highest food waste generation rate; however,

this figure was based only on one meal time (Sunday 4/5/2014) which was a particularly wasteful occasion (see paragraph above). The breakfast buffet had the second highest food waste generation rate at 1.2 kg per customer served, followed by the lunch time buffet with 1.1 kg per customer and dinner time buffet and 'a la carte' service, with 1 kg per customer. If the outlier of the lunch time 'a la carte' meal was excluded, the figures suggested that buffet style service was overall more wasteful than 'a la carte' service. Buffet service had lower preparation waste per customer rates, as explained by economies of scale; however, it produced substantial amounts of buffet leftover, making it a more wasteful type of service.

The patterns from the data in Table 6 and Table 7 and the subsequent observations of food preparation and consumption demonstrate how food waste generation was affected by the type of service provided (for example 'a la carte' as opposed to buffet) and food consumption practices of the customer (as influenced by values and cultural beliefs). Food waste from buffet operations was highly dependent on the types of individual events and functions taking place every day, causing daily variations in the amount of food waste. In addition to the type of service provided, the nature of the restaurant was such that the majority of the food was cooked from scratch, using fresh ingredients and very few processed items. This led to having all the preparation waste associated with a certain meal, produced within the restaurant and not in previous stages of the food supply chain, e.g. food processing industries.

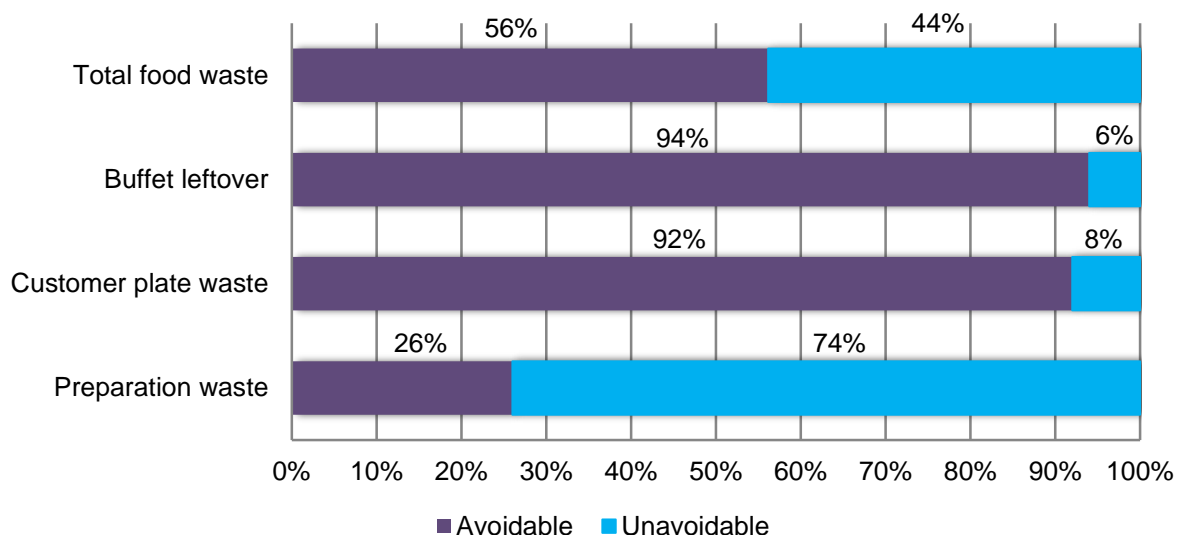


Figure 12: Avoidable and unavoidable food waste fractions of food waste

Another important feature of food waste generation was the percentages of avoidable and unavoidable fractions of food waste. As Figure 12 illustrates, 56% of all food waste generated in this case study was avoidable, which shows the significant scope for food waste prevention. At the preparation stage, the majority of food waste was unavoidable

as it comprised of mainly inedible parts of foods, such as bones, seafood shells, inedible fruit skins and cores etc. Buffet leftover was mainly edible, with an avoidable fraction of 94%. Food waste from the customer's plate was a mix of inedible parts such as bones, seafood shells etc., and edible surplus food. The unavoidable fraction measured in this case study (44% of total food waste) was significantly higher than the one (Betz et al., 2015) report (maximum 21% unavoidable fraction). This was due to the nature of the restaurant in this case study: high quality food prepared from scratch resulting in high preparation waste consisting of inedible parts such as bones and exotic fruit skins for example. The second reason was that, in this study, the possibly avoidable food waste fraction was reported within the unavoidable fraction. These type of variations, due to the subjective nature of definitions of avoidable and unavoidable fractions, as well as due to the extent which the restaurant used pre-prepared food, were acknowledged by (Betz et al., 2015) as well.

The next step to the analysis involved the generation of three Sankey diagrams illustrating the economic and material flows from food provisioning to food consumption. According to the analysis of incoming food and the outgoing food waste, it was calculated that approximately 30% of purchased food was lost in the form of food waste (no re-use of surplus food waste was observed in this case study) (see Figure 13). In more detail, approximately 17% of food was lost during preparation, 7% as customer plate waste and 6% as buffet leftover waste. The total food waste rate was higher than the average 20% reported by (Beretta et al., 2013), however lower than the maximum food loss they encountered during their study, of 45% at a gourmet restaurant. In Figure 13 the liquid fraction was included within the incoming food, food consumed and food waste and it was not shown separately. Meat and dairy represented 10% and 8% of incoming food, however only 1% and 0.2% of these food commodities respectively left the restaurant in the form of waste (see Figure 14). However, vegetables, cereal and fruit represented the three most wasted food commodities. These results corresponded to visual observations of the most commonly wasted food items, these being rice, noodles, cakes and desserts, as buffet leftovers and customer plate waste, and fruit and vegetables as preparation waste. They also corresponded with reports by other studies (Betz et al., 2015).

Figure 15 shows the economic flows that took place within the restaurant, broken down in the nine food commodity groups. This graph provides a different perspective to the previous graphs. It shows that although the liquid fraction was the most significant waste component in terms of weight (55% of total waste) it was not significant in economic terms. In contrast, cereal, vegetables, fruits, fish and seafood were the biggest economic losses of the system.

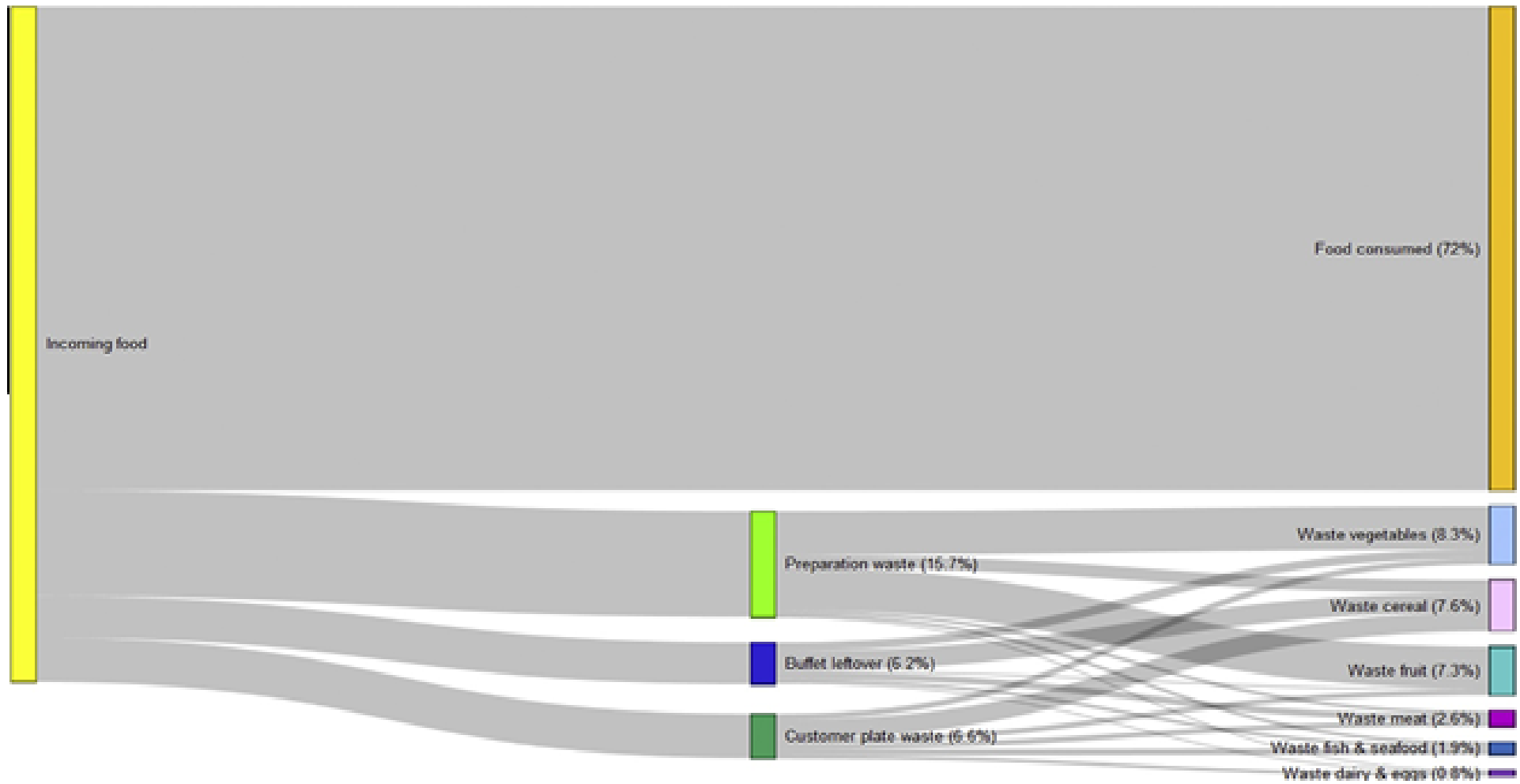


Figure 13: Material flows. Using software by Bostok (2014)

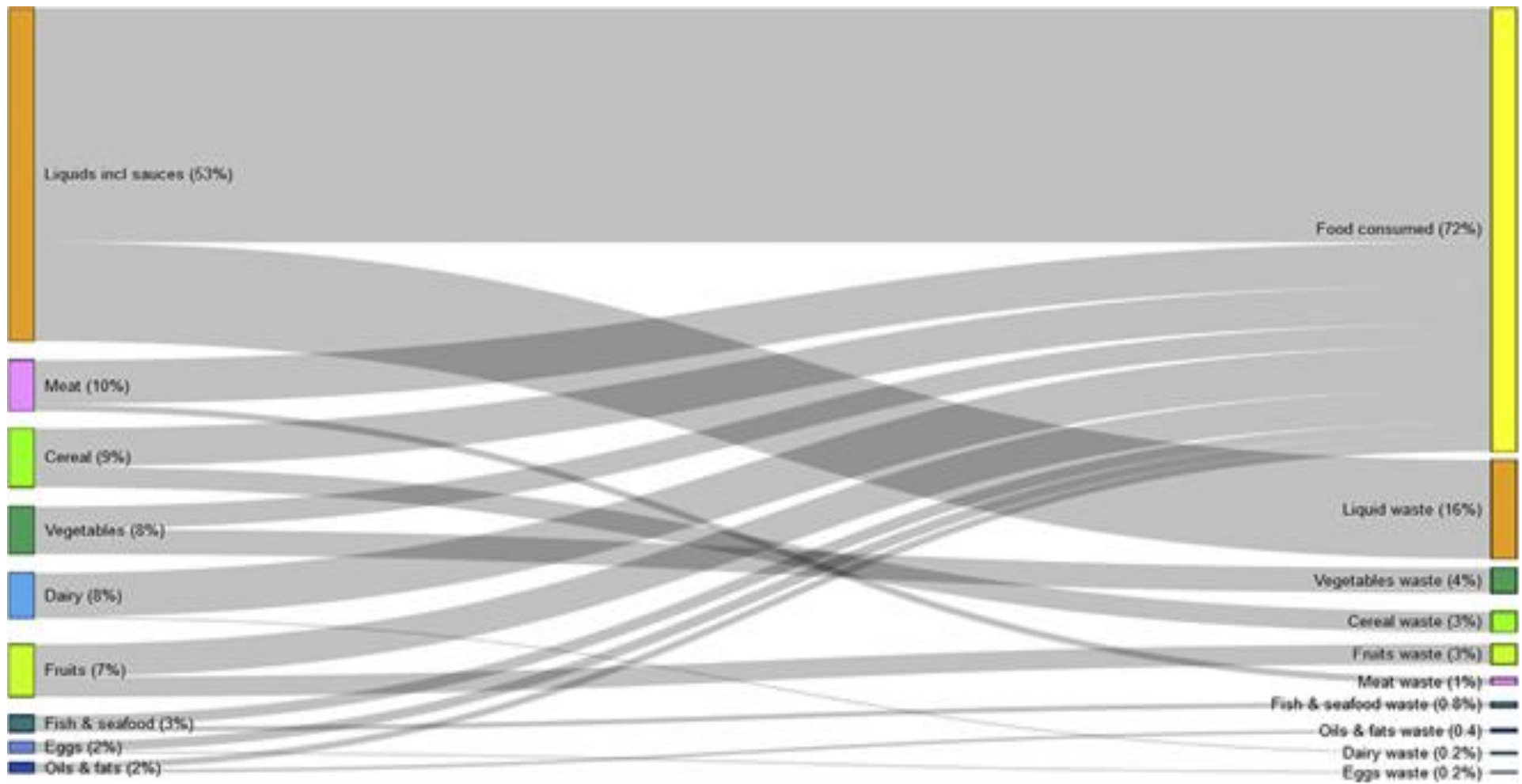


Figure 14: Material flows in terms of food commodities. Using software by Bostok (2014)

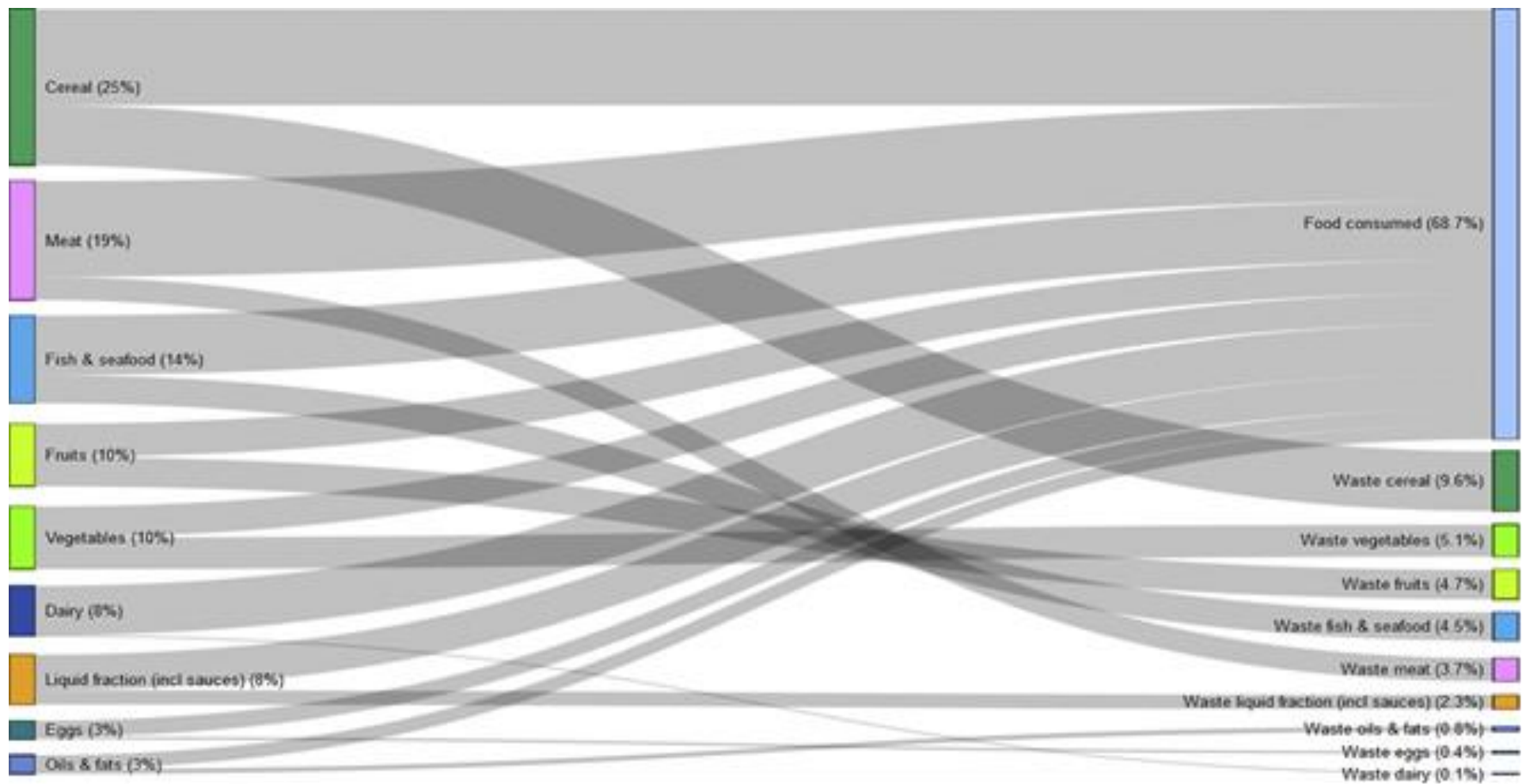


Figure 15: Economic flows. Using software by Bostok (2014)

The eco-efficiency analysis of the food commodities is presented in Figure 16. Cereal, fish and seafood appear at the top right quarter of the graph, representing food commodities that are both costly and generate high amounts of waste, hence have a lower eco-efficiency³ than the other food commodities. Fruits, vegetables, sauces, oils and fats are relatively less costly even though they generated higher amount of waste, and could be classified as having a medium eco-efficiency comparatively to the other food items. Meat, dairy, eggs, generated the least waste and were less costly when compared to the high cost foods such as fish and seafood, giving them a higher eco-efficiency rating. Figure 16 could help the restaurant focus and prioritise its food prevention strategy, starting with low eco-efficiency items (high cost - high waste group), followed by the medium eco-efficiency items (low cost – high waste group), and finally the high eco-efficiency items (low cost – low waste group).

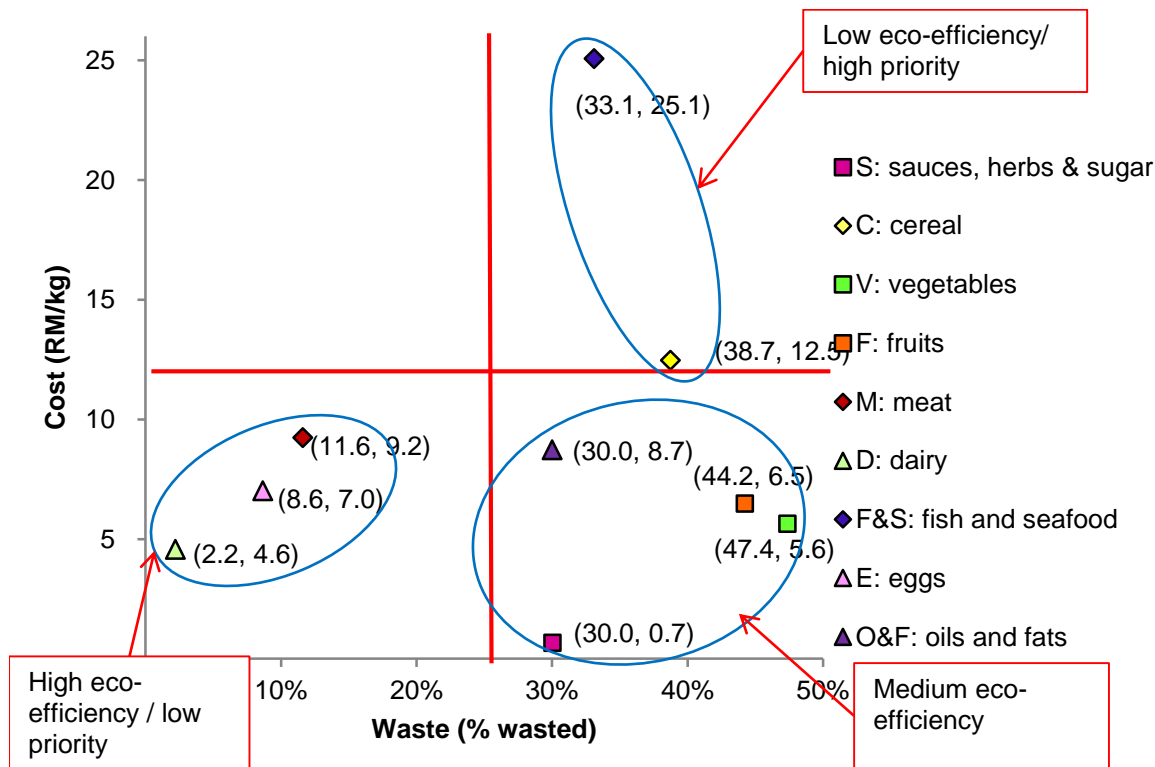


Figure 16: Eco-efficiency of food commodities

³ In this study cereal is a high cost food commodity group, due to the high cost per weight of bread, pastries and other bakery products included in this category. The restaurant buys these items prepared from a bakery, therefore preparation labour costs plus mark-up for convenience, are already included in their price. The cost of labour of the restaurant staff preparing food on site is not taken into account in the calculation of the food cost for items prepared on site. A more detailed eco-efficiency analysis could also consider preparation costs for food preparation.

3.5.2 *Food provisioning and restaurant operations as drivers of food waste generation*

Observations of the general procedures and practices outside the kitchen revealed a number of broader factors effecting food waste generation. These factors had to do with the way the restaurant operated and provisioned food. For example, in buffet operations food was prepared in advance. The quantity of food to be prepared was based on the reservations made and estimates of additional customers turning up on the day without any reservation. Accurate prediction of the number of customers to prepare food for was crucial in avoiding food surplus. In other words, if food was prepared for the actual number of customers being served, then food waste could be minimised. In order to achieve this, pre-booking was essential. This driver for food waste generation became apparent during the interview with the Head Chef of the restaurant:

Researcher: “Why do you think the buffet is more wasteful than the ‘a la carte’?”

Chef: “You see this is an upmarket place, we need to make sure that the first and the last customer that comes through that door gets the same variety of food and also sees the buffet full. That way he feels he gets good value for money. We take bookings but we also accept ‘walk-ins’, and you can never guess if a large group will come in suddenly just before we close the lunch buffet. So I need to prepare at least 30% more food than what I need based on the bookings.”

Researcher: “But then you end up wasting a lot of food”

Chef: “Well yes, but it’s better to waste food than lose the customer right?”

This interview revealed how the restaurants’ practice of preparing 30% more food than what was required by the reservations led to food surplus. It also revealed that the food surplus served to satisfy the customers’ expectations for variety and ‘value for money’. This strategy ensured the lunch time buffet did not run out of food; however, it also contributed to excessive food surplus production, which in turn led to significant buffet leftover food waste.

Another driver for food waste generation related to the restaurant’s operation was uncovered through participant observation and was later confirmed in interviews with the restaurant’s manager. This driver related to the strict policy on the maximum time duration food can be left on the buffet. The policy specified that food items should not be left on the buffet for periods longer than four hours. For example, if a dish was served during the breakfast buffet and it was not consumed, it could not be served again during lunch time and had to be discarded. Although the policy aimed to ensure

the food served was fresh and safe for the customer's benefit, it led to significant quantities of buffet leftover waste.

The focus group revealed another contributing factor to food waste generation due to poor communication and coordination between the different departments in charge of bookings (sales department), food provisioning (purchasing department), food preparation (kitchen), and operations (waiting staff). This was especially relevant in instances where changes are made to the initial booking. In the focus group discussion, it became apparent that effective communication and coordination was sometimes problematic, especially since the different departments had different and often conflicting priorities. The overall mission and values of the departments were the same and in line with the restaurant's policy. However, when these values were translated into department specific targets, conflicts became evident. An example of this was apparent within the departmental evaluation system. An excerpt from the focus group explains how this became apparent:

Kitchen staff: "but when changes happen in the bookings, sales never let us know on time. They let the client make last minute changes on the numbers and even the menu and we're the last ones to know. By that point we have to act fast to change the preparation and then we waste a lot of food."

Researcher: "How do these changes effect the purchasing of food?"

Purchasing staff: "We take the orders from the kitchen on what they need a week before. We need to keep costs down, so we can't make last minute changes to the order because then we won't get the best price for the produce. We buy a bit more than what we need, you know especially for things that keep longer, but if the booking changes then the kitchen has to deal with it." Sales staff: "we know this causes problems in the kitchen, but we can't turn down the costumer request. We need repeat business and if we start telling them they can't change the booking then they'll not come back"

The restaurant manager confirmed that the sales department was evaluated on the volume and economic value of bookings, the purchasing department on ensuring costs remained low, and the kitchen and operation staff on the quality of service and food, hence creating conflicts between the departments.

The case study revealed the significant potential for food waste prevention in this particular restaurant, considering the high avoidable waste percentage (56%). A key recommendation for preventing food waste is offering 'a la carte' rather than buffet style service; however, when buffet style service is offered operating at full capacity can

maximize the benefits of economies of scale, and actively encouraging more accurate prediction of customer numbers rather than relying on preparing 30% surplus food could make the buffet less wasteful. Additional food waste prevention strategies include targeting the commonly wasted items such as fruits and vegetables by improving food preparation techniques, as well as the most commonly wasted dishes such as rice, noodles, cakes and desserts, by reducing portion sizes. Increasing the eco- efficiency of fish, seafood and cereals should also be a priority. Revisiting the blanket buffet food safety policy in order to allow chefs to decide on a case by case basis how long dishes should remain on the buffet has the potential for further food waste reductions. Realigning targets of the different departments in the restaurant and connecting them back into the company's central values could result in better communication and coordination between the departments, which in turn has the potential for further food waste reduction.

3.6 Conclusion

This paper proposes a conceptual framework in investigating food waste in the hospitality sector. The conceptual framework can help to identify and explain patterns of food waste generation, and to establish the main drivers for it. The strength of this approach is demonstrated through a comprehensive case study of food waste generation in a hotel restaurant. The empirical data that emerged from the case study is one contribution of this study; however, the main contribution of this paper is the actual conceptual framework for studying food waste generation and prevention that was developed.

The conceptual framework for studying food waste generation and prevention has an interdisciplinary nature, developed through integrating methods from ethnography and grounded theory, and complementing them with concepts and tools from industrial ecology. This synthesis of tools, methods and research strategies achieves what has been problematic so far: to link the biophysical flows of food provisioning and waste generation, with the social and cultural practices associated with food consumption. It demonstrates that food waste is intrinsically linked to the way we provision and consume food, the material and socio-cultural context of food consumption and food waste generation. Hence, food consumption and food waste generation should be studied together, rather than separately, in order to fully understand how, where and most importantly why food waste is generated. This understanding will then enable research to draw detailed, case specific food waste prevention plans addressing both the material and socio-economic aspects of food waste generation.

The conceptual framework presented in this paper has potential applications beyond the research field of food waste management. The interdisciplinary nature of this conceptual framework allows the researcher to combine qualitative and quantitative data collection and analysis tools, methods and research strategies, in order to understand a complex issue such as food waste. The conceptual framework can link biophysical flows with social and cultural practices that define research problems in fields that have in the past focused either on the material or the social aspects, but have fallen short of connecting the two. The framework should be applied as an adaptive approach, not as a set of rigid procedures, in other research contexts where understanding both the material and the social, cultural and economic aspects of the problem is essential in providing a comprehensive solution. As such, the conceptual framework can also be used to study for example food consumption and solid waste management. Applying the framework in other contexts can help refine it and verify it.

3.7 References

- Ayres, R. U. (1989). Industrial Metabolism, in: Ausukl, J. H. and Sladovich, H. E. (Eds.), *Technology and environment*, (pp. 23–49). Washington, D.C.: National Academy Press.
- Baccini, P. & Brunner, P. H. (1991). *Metabolism of the Anthroposphere*. Berlin: Springer-Verlag.
- Beretta, C., Stoessel, F., Baier, U. & Hellweg, S. (2013). Quantifying Food Losses and the Potential for Reduction in Switzerland. *Waste Management*, 33(3), 764–773. Retrieved from <http://dx.doi.org/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 Management*, 35, 218–226. Retrieved from <http://dx.doi.org/10.1016/j.wasman.2014.09.015>
- Bostok, M. (2014). Sankey Diagrams Software. Retrieved March 5, 2015, from ramblings.mcpher.com
- Brunner, P. H. & Rechberger, H. (2004). Practical Handbook of Material Flow Analysis, in: *The International Journal of Life Cycle Assessment*, (pp. 337–338). Florida: Lewis Publishers.
- Bryant, A. & Charmaz, K. (Eds.) (2007). *The SAGE Handbook of Grounded Theory*. London: SAGE Publications Ltd.

- Charmaz, K. (2014). *Constructing Grounded Theory*. London: SAGE Publications Ltd.
- Cohen, M. J. (2015). Supplementing the Conventional 3R Waste Hierarchy, in: Karin M., E. (Ed.), *Waste Management and Sustainable Consumption: Reflections on Consumer Waste*. New York: Routledge.
- Corbin, J. & Strauss, A. (2008). *Basics of Qualitative Research*. London: SAGE Publications Ltd.
- Crang, M. & Cook, I. (2007a). Interviewing, in: *Doing Ethnographies*, (pp. 60–90). London: SAGE Publications Ltd. Retrieved from <http://www.gees.bham.ac.uk/research/>
- Crang, M. & Cook, I. (2007b). Focus Groups, in: *Doing Ethnographies*, (pp. 90–103). London: SAGE Publications Ltd.
- Delbridge, R. & Kirkpatrick, I. (1994). Theory and Practice of Participant Observation, in: Wass, V. and Wells, P. (Eds.), *Principles and Practice in Business and Management Research*, (pp. 35–62). Aldershot: Dartmouth.
- Deutz, P. & Ioppolo, G. (2015). From Theory to Practice: Enhancing the Potential Policy Impact of Industrial Ecology. *Sustainability*, 2259–2273.
- Edwards, F. & Mercer, D. (2007). Gleaning from Gluttony: An Australian Youth Subculture Confronts the Ethics of Waste. *Australian Geographer*, 38(3), 279–296. Retrieved July 4, 2012, from <http://www.tandfonline.com/doi/abs/10.1080/00049180701639174>
- Emerson, R. M., Fretz, R. I. & Shaw, L. L. (2001). Participant Observation and Fieldnotes, in: *Handbook of Ethnography*, (pp. 352–369). London: SAGE Publications Ltd.
- Evans, D. (2011). Beyond the Throwaway Society: Ordinary Domestic Practice and a Sociological Approach to Household Food Waste. *Sociology*, 46(1), 41–56. Retrieved March 10, 2012, from <http://soc.sagepub.com/cgi/doi/10.1177/0038038511416150>
- Evans, D. (2014). *Food Waste. Home Consumption, Material Culture and Everyday Life*. London: Bloomsbury Academic.
- Evans, D., Campbell, H. & Murcott, A. (2013). *Waste Matters: New Perspectives on Food and Society* (D. Evans, H. Campbell, and A. Murcott, Eds.). Oxford: Wiley-Blackwell/ The Sociological Review.

- FAO. (2014). *Global Initiative on Food Losses and Waste Reduction*. Rome.
- Fischer-Kowalski, M. & Huttler, W. (1999). Society's Metabolism. The Intellectual History of Materials Flow Analysis, Part II, 1970-1998. *Journal of Industrial Ecology*, 2(4).
- Gabriel, R. & Braune, A. (2005). Eco-Efficiency Analysis: Applications and User Contacts. *Journal of Industrial Ecology*, 9(4), 19–21.
- Gai, R., Kuroiwa, C., Xu, L., Wang, X., Zhang, Y., Li, H., et al. (2009). Hospital Medical Waste Management in Shandong Province, China. *Waste management & research: the journal of the International Solid Wastes and Public Cleansing Association, ISWA*, 27(4), 336–342.
- Gardner, B. & Abraham, C. (2007). What Drives Car Use? A Grounded Theory Analysis of Commuters' Reasons for Driving. *Transportation Research Part F: Traffic Psychology and Behaviour*, 10(3), 187–200.
- Garrone, P., Melacini, M. & Perego, A. (2014). Opening the Black Box of Food Waste Reduction. *Food Policy*, 46, 129–139. Retrieved from <http://dx.doi.org/10.1016/j.foodpol.2014.03.014>
- Gill, J. & Johnson, P. (2002). *Research Methods for Managers*. London: Sage Publications.
- Glaser, B. (1978). *Theoretical Sensitivity*. Mill Valley, CA: Sociology Press.
- Glaser, B. & Strauss, A. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. New York: Aldine DeGruyter.
- Gobo, G. (2008a). Doing Ethnography, in: *Doing Ethnography*, (pp. 2–15). London: SAGE Publications Ltd.
- Gobo, G. (2008b). Method or Methodology? Locating Ethnography in the Methodological Landscape, in: *Doing Ethnography*, (pp. 15–32). London: SAGE Publications Ltd.
- Goggins, G. & Rau, H. (2015). Beyond Calorie Counting: Assessing the Sustainability of Food Provided for Public Consumption. *Journal of Cleaner Production*. Retrieved from <http://linkinghub.elsevier.com/retrieve/pii/S0959652615007647>
- Goonan, S., Miroso, M. & Spence, H. (2014). Getting a Taste for Food Waste: A Mixed Methods Ethnographic Study into Hospital Food Waste before Patient Consumption Conducted at Three New Zealand Foodservice Facilities. *Journal of*

the Academy of Nutrition and Dietetics, 114(1), 63–71. Retrieved from <http://dx.doi.org/10.1016/j.jand.2013.09.022>

Graham-Rowe, E., Jessop, D. C. & Sparks, P. (2014). Identifying Motivations and Barriers to Minimising Household Food Waste. *Resources, Conservation and Recycling*, 84, 15–23. Retrieved from <http://dx.doi.org/10.1016/j.resconrec.2013.12.005>

Gregson, N., Crang, M., Laws, J., Fleetwood, T. & Holmes, H. (2013). Moving up the Waste Hierarchy: Car Boot Sales, Reuse Exchange and the Challenges of Consumer Culture to Waste Prevention. *Resources, Conservation and Recycling*, 77, 97–107. Retrieved January 30, 2014, from <http://linkinghub.elsevier.com/retrieve/pii/S0921344913001353>

Gustavsson, J., Cederberg, C., Sonesson, U., Otterdijk, R. van & Meybeck, A. (2011). *Global Food Losses and Food Waste. Extent, Causes and Prevention*. Rome.

Hetherington, K. (2004). Second-Handedness: Consumption, Disposal and Absent Presence. *Environment and Planning D: Society and Space*, 22(1), 157–173.

Huppes, G. & Ishikawa, M. (2005). A Framework for Quantified Eco-Efficiency Analysis. *Journal of Industrial Ecology*, 9(4), 25–41.

Lozano, R. (2013). *A Holistic Perspective on Corporate Sustainability Drivers. Corporate Social Responsibility and Environmental Management*.

Martin, M., Williams, I. D. & Clark, M. (2006). Social, Cultural and Structural Influences on Household Waste Recycling: A Case Study. *Resources, Conservation and Recycling*, 48, 357–395.

Mena, C., Terry, L. a., Williams, A. & Ellram, L. (2014). Causes of Waste across Multi-Tier Supply Networks: Cases in the UK Food Sector. *International Journal of Production Economics*, 152, 144–158. Retrieved from <http://dx.doi.org/10.1016/j.ijpe.2014.03.012>

Newenhouse, S. C. & Schmit, J. T. (2000). Qualitative Methods Add Value to Waste Characterization Studies. *Waste Management & Research*, 18(2), 105–114.

Okazaki, W. K., Turn, S. Q. & Flachsbart, P. G. (2008). Characterization of Food Waste Generators: A Hawaii Case Study. *Waste management*, 28(12), 2483–94. Retrieved June 18, 2012, from <http://www.ncbi.nlm.nih.gov/pubmed/18375111>

Padfield, R. (2011). *Neoliberalism and the Polarizing Water Geographies of the*

Zambian Copperbelt. *Waterlines*, 30(2), 150–164.

Padfield, R., Waldron, S., Drew, S., Papargyropoulou, E., Kumaran, S., Page, S., et al. (2015). Research Agendas for the Sustainable Management of Tropical Peatland in Malaysia. *Environmental Conservation*, 42(1), 73–83.

Papargyropoulou, E., Lozano, R., K. Steinberger, J., Wright, N. & Ujang, Z. Bin. (2014). The Food Waste Hierarchy as a Framework for the Management of Food Surplus and Food Waste. *Journal of Cleaner Production*, 76, 106–115. Retrieved May 28, 2014, from <http://linkinghub.elsevier.com/retrieve/pii/S0959652614003680>

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 Management*, 35, 207–217. Retrieved from <http://dx.doi.org/10.1016/j.wasman.2014.09.019>

Pirani, S. I. & Arafat, H. a. (2015). Reduction of Food Waste Generation in the Hospitality Industry. *Journal of Cleaner Production*. Retrieved from <http://linkinghub.elsevier.com/retrieve/pii/S095965261501077X>

Pires, A., Martinho, G. & Chang, N. (2011). Solid Waste Management in European Countries: A Review of Systems Analysis Techniques. *Journal of Environmental Management*, 92(4), 1033–1050. Retrieved from <http://dx.doi.org/10.1016/j.jenvman.2010.11.024>

Quested, T. E., Marsh, E., Stunell, D. & Parry, D. (2013). Spaghetti Soup: The Complex World of Food Waste Behaviours. *Resources, Conservation & Recycling*, 79, 43–51. Retrieved from <http://dx.doi.org/10.1016/j.resconrec.2013.04.011>

Quested, T. E., Parry, D., Easteal, S. & Swannell, R. (2011). Food and Drink Waste from Households in the UK. *Nutrition Bulletin*, 36(4), 460–467. Retrieved July 3, 2012, from <http://doi.wiley.com/10.1111/j.1467-3010.2011.01924.x>

Rieckhof, R., Bergmann, A. & Guenther, E. (2014). Interrelating Material Flow Cost Accounting with Management Control Systems to Introduce Resource Efficiency into Strategy. *Journal of Cleaner Production*, 2011. Retrieved from <http://dx.doi.org/10.1016/j.jclepro.2014.10.040>

Sahakian, M. D. & Steinberger, J. K. (2011). Energy Reduction Through a Deeper Understanding of Household Consumption: Staying Cool in Metro Manila. *Journal of Industrial Ecology*, 15(1), 31–48.

- Saunders, M., Lewis, P. & Thornhill, A. (2009). *Research Methods for Business Students*. Harlow: Pearson Education Ltd.
- Schmidt, M. (2008). The Sankey Diagram in Energy and Material Flow Management: Part I: History. *Journal of Industrial Ecology*, 12(1), 82–94.
- Seppälä, J., Melanen, M., Mäenpää, I., Koskela, S., Tenhunen, J. & Hiltunen, M.-R. (2005). How Can the Eco-Efficiency of a Region Be Measured and Monitored? *Journal of Industrial Ecology*, 9(4), 117–130. Retrieved from <http://www.scopus.com/inward/record.url?eid=2-s2.0-84876901083&partnerID=tZOtx3y1>
- Sherman Heyl, B. (2001). Ethnographic Interviewing, in: *Handbook of Ethnography*, (pp. 369–379). London: SAGE Publications Ltd.
- Sustainable Restaurant Association. (2010). *Too Good to Waste*. Restaurant Food Waste Survey Report. London.
- Walsh, I., Holton, J., Bailyn, L., Fernandez, W., Levina, N. & Glaser, B. (2015). What Grounded Theory Is. *A Critically Reflective Conversation Among Scholars*. *Organizational Research Methods*, 1–19.
- WBCSD. (2000). *Eco-Efficiency. Creating More Value with Less Impact*. Retrieved from <http://www.wbcsd.org>
- Wilkie, A., Graunke, R. & Cornejo, C. (2015). Food Waste Auditing at Three Florida Schools. *Sustainability*, 7(2), 1370–1387. Retrieved from <http://www.mdpi.com/2071-1050/7/2/1370/>
- WRAP. (2011). *The Composition of Waste Disposed of by the UK Hospitality Industry*. Banbury.
- WRAP. (2013). *Overview of Waste in the UK Hospitality and Food Service Sector*. Banbury.
- XE Currency Converter. (2015). XE Currency Converter. Retrieved September 2, 2015, from <http://www.xe.com/currencyconverter>
- Zhao, W., Huppes, G. & van der Voet, E. (2011). Eco-Efficiency for Greenhouse Gas Emissions Mitigation of Municipal Solid Waste Management: A Case Study of Tianjin, China. *Waste Management*, 31(6), 1407–1415. Retrieved from <http://dx.doi.org/10.1016/j.wasman.2011.01.013>

Chapter 4: Patterns and causes of food waste in the hospitality and food service sector: A comparative analysis of five case studies from Malaysia

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4.1 Abstract

Food waste has formidable detrimental impacts on food security, the environment and the economy, which makes it a global challenge that requires urgent attention. This study investigates the patterns and causes of food waste generation in the hospitality and food service sector, with the aim of identifying the most promising food waste prevention measures. It presents a comparative analysis of five case studies from the hospitality and food service sector in Malaysia and uses a mixed methods approach. This paper provides new empirical evidence to highlight the significant opportunity and scope for food waste reduction in the hospitality and food service sector. The findings suggest that the scale of the problem is even bigger than previously thought. Nearly one third of all food was wasted in the case studies presented, and almost half of it was avoidable. Preparation waste was the largest fraction, followed by buffet leftover and then customer plate waste. Food waste represented an economic loss equal to 23% of the value of the food purchased. Causes of food waste generation included the restaurants' operating procedures and policies, and the social practices related to food consumption. Therefore, food waste prevention strategies should be twofold, tackling both the way the hospitality and food service sector outlets operate and organise themselves, and the customers' social practices related to food consumption.

Key words: food waste, food loss, hospitality, food service sector, food waste prevention

4.2 Introduction

One third of food produced globally for human consumption is lost or wasted, which amounts to approximately 1.3 billion tons per year (Gustavsson et al., 2011). Food waste's formidable economic, environmental and social impacts have been recognised at the highest levels of global governance. The UN's sustainable development goal for responsible consumption and production urges the world to "*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*" by 2030 (United Nations, 2015). The FAO (2015) recently launched the 'Global initiative on food loss and waste reduction' aiming to reduce food wastage throughout the food system by facilitating collaboration, coordination, and research and by raising awareness.

In this backdrop of growing interest on food waste, this study investigates food waste generation in the hospitality and food service sector (for definition of the hospitality and food service sector refer to WRAP, 2013). The patterns and causes of food waste generation are explored to identify the most promising measures for food waste prevention. This paper presents a comparative analysis of five case studies from the hospitality and food service sector in Malaysia. The study positions itself in the interface between quantitative and qualitative research, drawing on methods from ethnography and grounded theory, complemented with concepts and tools from industrial ecology.

4.3 Literature review

Food waste is a growing issue due to its environmental (Garnett, 2011; Gustavsson et al., 2011; Padfield et al., 2012), economic (Nahman and de Lange, 2013; Dias-Ferreira et al., 2015; Papargyropoulou et al., 2015; Buzby and Hyman, 2012) and social implications (Schneider, 2013; Edwards and Mercer, 2007; Evans et al., 2013). Food waste has high carbon, water and ecological footprint (Song et al., 2015; Abeliotis et al., 2015; Scholz et al., 2014), as well as negative impacts on cropland and fertiliser use (Kummu et al., 2012). Most importantly, it is recognised that food waste reduction has an important role to play in the quest for global food security (Parfitt et al., 2010; Garnett, 2014; Dou et al., 2016).

Academic research on food waste has focused on developed countries (Thi et al., 2015) and households (Chen et al., 2016). The material and social contexts of food waste practices (Evans, 2011) and in particular awareness around food and waste matters (Parizeau et al., 2015; Secondi et al., 2015), lifestyle (Mallinson et al., 2016), food shopping, preparation and consumption behaviours (Stefan et al., 2013; Stancu et al., 2016) are central in understanding household food waste. Discussions on

household food waste centre around waste separation behaviour, especially in highly density housing areas (Bernstad, 2014; Miliute-Plepiene and Plepys, 2014), waste prevention (Rispo et al., 2015; Visschers et al., 2016), and the perspective of the consumer, namely how consumers experience aversion when they waste food (Bolton and Alba, 2012) and how food consumption practices influence waste generation (Evans, 2014; Leray et al., 2016).

Beyond the household focus, studies have examined the scale and nature of food losses and waste in the entire food chain expressed in weight, calorific content and economic value (Beretta et al., 2013; Katajajuuri et al., 2014; Parfitt et al., 2010). In hospitals case studies have highlighted the scale of the food waste problem (Dias-Ferreira et al., 2015), shown how catering practices and public procurement impact food waste generation (Sonnino and McWilliam, 2011), and how reduced portion sizes, bulk meal delivery systems, improved forecasting, and provision of dining rooms can be effective food waste minimisation strategies (Williams and Walton, 2011; Goonan et al., 2014). Research focusing on the retail sector highlights the complex and varied causes of food waste, and suggests multifaceted prevention approaches (Lebersorger and Schneider, 2014; Mena et al., 2011). In the food industry, studies argue that clearer communication and stronger cooperation amongst the main actors in the food supply are essential for food waste reduction, through waste avoidance and donations of edible fractions to charitable organisations (Giroto et al., 2015; Richter and Bokelmann, 2016). Case studies in universities have explored food waste reduction interventions such as tray-less delivery systems (Thiagarajah and Getty, 2013), written messages encouraging pro-environmental behaviour (Whitehair et al., 2013) and a social media based food sharing tool (Lazell, 2016) with mixed results. Finally, in the hospitality and food service sector research has focused on quantifying waste (Betz et al., 2015; Pirani and Arafat, 2015), suggested that food buffet services and overproduction are two of the main causes of food waste (Silvennoinen et al., 2015), and revealed that 'nudging' techniques can leading to food waste minimisation (Kallbekken and Sælen, 2013).

These studies have attempted to quantify food waste and understand the processes that give rise to it in order to propose recommendations for food waste reduction (Halloran et al., 2014; Thyberg and Tonjes, 2016; WRAP, 2013). Food waste prevention has been recognised as the most advantageous option for addressing food waste (Herszenhorn et al., 2014), and food surplus management identified as essential in achieving prevention (Garrone et al., 2014). Food surplus management includes the redistribution to people affected by food poverty as a means of achieving food waste reduction and urban food security (Alexander and Smaje, 2008; Cicatiello et al., 2016).

However, the role that food surplus redistribution can play towards realising sustainable food is questioned (Midgley, 2013; Schneider, 2013). It is argued that food surplus donations through civil society organisations in fact depoliticise food issues, focus on individual personal responsibility, and fail to address structural poverty (Warshawsky, 2015; Collins et al., 2014).

4.4 Methods

Five case studies from the hospitality and food service sector in Malaysia were selected based on access availability, type of food service (such as buffet style, *a la carte*, combination of the two), price range, type of cuisine, type of customers, primary function (such as work place canteen, hotel restaurant, banquet facility, standalone restaurant) and size (number of meals served per day). The selected case studies did not aim to give a comprehensive picture of the whole hospitality and food service sector, but instead to offer opportunities to test how these variables affect food waste generation and prevention (for more details on the case studies please refer to Table 8). Food waste generation was studied from the time of purchasing raw food supplies, throughout food storage, preparation and cooking, customer consumption and finally discarding of food waste. It did not include waste collection and final disposal at the landfill or other waste treatment facilities, as these stages were outside the remit and control of the restaurants.

Mixed methods were used for data collection and analysis. The study of food waste and prevention followed the conceptual framework presented in detail in Papargyropoulou et al. (2016). Quantitative data collection methods used in the case studies aimed to identify processes and activities within the restaurant that give rise to food waste. They were used to measure the amount of food waste generated from these processes in order to prioritise the most promising measures for waste prevention. The quantitative data collection methods comprised of a food waste audit, photographic records, collation of financial records and inventory of food purchases. During the food waste audit, the amount and type of food waste were measured and recorded continuously throughout the day and for sufficient length of time (continuously for one week) in order to account for weekly variations patterns. Building on previous research (Sustainable Restaurant Association, 2010), three types of food waste were monitored. 'Preparation waste': produced during the food preparation stage, due to overproduction, peeling, cutting, expiration, spoilage, overcooking etc. 'Customer plate leftover waste': food discarded by customers after the food has been sold or served to them. 'Buffet leftover waste': excess food that has been prepared but has not been taken onto the customer's plate or consumed thus left on the buffet or a food storage area and later on discarded. The ingredients of the food waste were also recovered in

order to categorise food and food waste into nine food commodity groups and produce detailed material flow diagrams. In addition to the amount of food waste generated and the process that gave rise to it, in-situ estimates of the edible fraction of food waste were made based on visual observations.

The weight and composition of the food waste were combined with the food purchasing inventory to calculate the economic losses due to food waste. Sankey flow diagrams were used to visualise the magnitude of the material flows taking place within the case studies. The thickness of each link represented the amount of flow from a source to a target node, in this occasion from food provisioning to food consumption.

Qualitative data collection and analysis methods complemented the quantitative methods. In-depth structured, and informal non-structured interviews of the employees from the restaurants and representatives of the National Solid Waste Management Department, were carried out. Following the initial round of in-depth interviews, participant observation combined with informal non-structured interviews with the restaurant employees were carried out while collecting quantitative data. Focus groups were also carried out following some preliminary data analysis. The main patterns emerging from the data were discussed in the focus groups comprising members of the management, procurement, sales, finance, food preparation and operations teams (for stakeholder engagement methods see Padfield et al., 2016; Padfield et al., 2015).

The conceptual framework for studying food waste generation and prevention was based on an inductive and iterative process in which theory was built and modified from the data collected. The constant comparative analysis method from grounded theory was applied by continually comparing sections of the data, to allow categories to emerge and for relationships between these categories to become apparent. The emerging categories were then modified into more abstract concepts. Theory on the patterns and causes of food waste generation was built by organising these concepts into logical frames. As new data emerged, new concepts were added until a point of 'saturation' was reached whereby new data no longer contributed anything new to the theory. The theory that was developed through this process explained how much, why and by whom food waste was produced and finally helped to identify the most promising measures for food waste prevention.

4.5 Results and discussion

The characteristics of the five case studies presented in this paper are summarised in Table 8. Case Study 1 (CS1) was a high-end banquet facility, serving food for a number of events every day such as conferences, meetings, weddings, promotional events, workshops and annual general meetings (Figure 17). It served on average 560

meals throughout the day, either buffet style or full table service to a variety of customers. Case Study 2 (CS2) was a mid to high-end standalone Chinese restaurant, serving *a la carte* lunch and dinner to approximately 210 customers a day. Case Study 3 (CS3) was a mid-range, buffet or *a la carte* style, Malay restaurant, serving approximately 160 meals a day. Case Study 4 (CS4) was a mid to high-end restaurant operating within a five-star hotel, and serving approximately 170 meals throughout the day, with buffet or *a la carte* service (Figure 18). Case Study 5 (CS5) was a university canteen comprising nine independently ran food outlets operating within the same 'food court' space. It offers more than 6,000 affordable meals throughout the day to university students and staff.



(a)



(b)



(c)



(d)

Figure 17: Food consumption and waste in Case Study 1: (a) Laid out table for a wedding, (b) Leftover food on serving dishes, (c) Buffet leftovers, (d) Fruit buffet leftovers (Papargyropoulou, 2012)



Figure 18: Food preparation and waste in Case Study 4: (a) The kitchen, (b) Kitchen staff preparing papaya fruits, (c) Preparation food waste comprising vegetable and fruit peelings (Papargyropoulou, 2014)

4.5.1 Patterns and causes of food waste generation

Food waste generation varied substantially amongst the case studies. Table 9 compares the case studies according to their average food waste generation per customer. On average 0.53kg of food waste was produced for every meal and customer served; however, the most wasteful restaurant (CS4) produced over eight times more waste per customer compared to the least wasteful restaurant (CS5). This result highlighted how case-specific conditions can have a very significant impact in food waste generation, as suggested by other studies (WRAP, 2011a; Al-Domi et al., 2011; Beretta et al., 2013; Betz et al., 2015). The top three restaurants in Table 9 offered buffets where the customer could enjoy unlimited food for a fixed price. In the least wasteful restaurants, the customers paid according to what they consumed. These results confirmed the hypothesis that ‘all you can eat’ buffets are more wasteful compared to the *a la carte* food service. The causes of these are presented below.

Table 8: Case studies details

	Size (av. no. of meals served per day)	Average meal price (RM/USD)	Type of service	Type of customer & function
Case Study 1: Banquet facility	560	RM80 – 250 (USD22-68)	Buffet (all you can eat) Full table service Lunch, dinner, mid – morning and mid-afternoon coffee breaks	Local families/ weddings, professionals on conferences, workshops, annual dinners, promotional events
Case Study 2: Chinese cuisine restaurant	210	RM60-150 (USD16-41)	A la carte Lunch, dinner	Local families, professionals in meetings, work colleagues

	Size (av. no. of meals served per day)	Average meal price (RM/USD)	Type of service	Type of customer & function
Case Study 3: Malay cuisine restaurant	160	RM40-100 (USD11- 28)	Buffet (all you can eat) A la carte Lunch, dinner	Local families, work colleagues, professionals in meetings
Case Study 4: Five-star hotel restaurant	170	RM80 - 130 (USD22 –35)	Buffet (all you can eat) A la carte Breakfast, lunch, dinner	Tourists, professionals in meetings, local families
Case Study 5: University food court	6,440	RM5 – 20 (USD1-4)	Canteen buffet (pay what you eat) Breakfast, lunch, dinner	Students and university staff

Table 9: Food waste per customer (kg/ customer)

	Min.	Max.	Average	Stand. Dev.
Case Study 4	0.67	1.68	1.12	0.36
Case Study 3	0.52	0.67	0.60	0.06
Case Study 1	0.28	0.72	0.43	0.15
Case Study 2	0.31	0.61	0.40	0.10
Case Study 5	0.08	0.26	0.13	0.06
All case studies	0.08	1.68	0.53	0.37

Preparation waste was 15-55%, buffet leftover 22-50% and customer plate waste 23-35% of total food waste, showing significant variation across the case studies (Figure 19)⁴. Significant variation has been reported in other studies where preparation waste was 5-31%, buffet leftover 7-44%, customer plate waste 4-37% (Pirani and Arafat, 2015). Customer plate was the smallest fraction of the food waste produced, contrary to the opinions of the restaurants' staff and management as revealed during the interviews and focus groups. The customer was often blamed for the high food waste generation rates (this could be representative of the broader individual focus of environmental policies see Evans, 2011; Shove, 2010; Maniates, 2001). The restaurant

⁴ Case Study 2 did not offer a buffet, therefore did not generate any buffet leftover waste. This led to the other two waste types e.g. preparation and customer plate food waste to appear seemingly higher as percentages of the total food waste.

staff and management, were surprised with the results of the study showing that a significant potential for food waste prevention was within the scope and power of the restaurant itself e.g. reducing preparation and buffet leftover waste.

Customer plate waste showed the least variation across the case studies, however preparation and buffet leftover was significantly different across the restaurants studied. The highest preparation waste percentage was observed in CS2, followed by CS4, CS5, CS1 and finally CS3. The order of the cases studies in terms of buffet leftover waste percentage from highest to lowest is the reverse i.e. CS3 has the highest percentage of buffet leftover, followed by CS1, CS5 and finally CS4 (CS2 did not offer a buffet, therefore is excluded from this analysis). These patterns are explained below: CS3 (Malay restaurant) is attached to CS1 (banquet hall) and operated by the same company. Buffet leftover from the banquet hall that had not been served was directed to the Malay restaurant and included in their buffet. This method reduced buffet leftover waste from the banquet hall and preparation waste from the Malay restaurant. It also made CS3 preparation waste percentage seemingly appear low and buffet leftover percentage to appear high.

Preparation waste percentage was the highest in CS2, CS4 and CS5. These were the restaurants where meals were prepared from scratch using fresh ingredients, leading to higher preparation waste rates. Poor cutting skills during food preparation was one of the contributing factors for high food wastage.

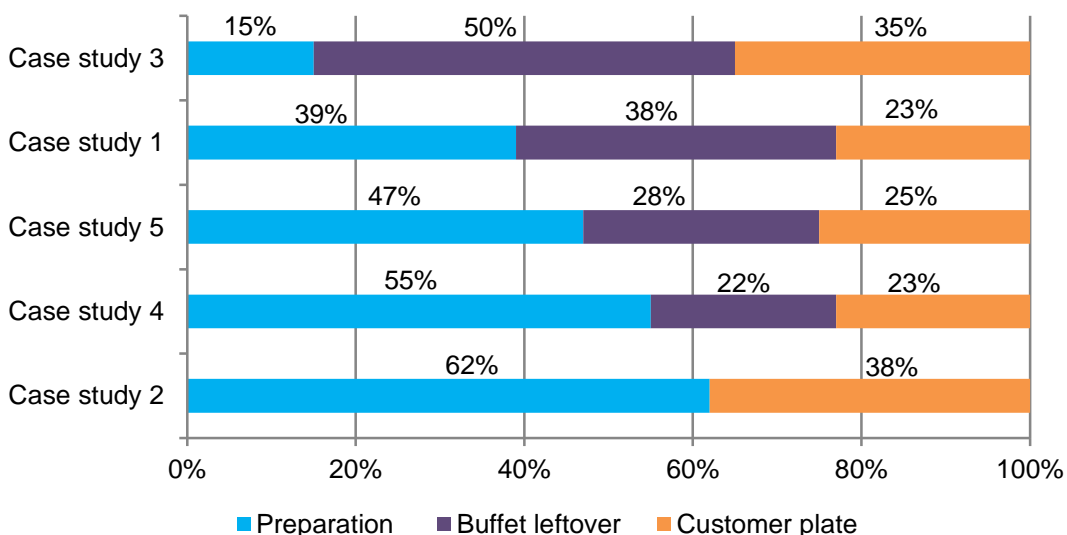


Figure 19: Percentages of preparation, customer plate and buffet leftover waste fractions

Avoidable food waste was 32–63% of total food waste across all case studies, illustrating the substantial potential for waste prevention (Figure 20). The avoidable fraction measured in this study is comparable the one reported by Beretta et al (2013)

at over two thirds of the total food waste. Preparation waste primarily consisted of unavoidable waste, such as inedible fruit and vegetable peelings, fruit stones, and bones. Customer plate waste had both inedible (unavoidable) and edible (avoidable) parts, whereas buffet leftover waste primarily consisted of edible (avoidable) parts.

CS3 (Malay restaurant) had the highest avoidable food waste fraction, due to the high buffet leftover rate. CS4 (hotel restaurant) had the second highest avoidable food waste fraction. Observations suggested that this was linked to the high preparation waste generated by the hotel restaurant due to high aesthetic standards (e.g. shaping a whole watermelon into a flower for buffet decoration) and cooking from scratch using fresh ingredients. A food safety policy stipulating that no food should remain on the buffet for a period longer than four hours, also led to increased buffet leftover waste.

Although CS1 (banquet hall) diverted some of the buffet leftover waste (primarily avoidable waste) to CS3 and therefore practiced waste prevention, it still had the third highest avoidable fraction at 55%. Observations, discussions during the focus group and the interviews revealed the following reasons behind food waste generation in CS1. As a banquet hall, CS1 catered for large functions such as weddings, conferences, workshops and marketing events. In many cases, the number of customers that turned up to these events was significantly lower than the number food was prepared for. In other occasions, changes in the booking details, such the menu and the number of participants, were made right up to the day of the event. In addition, the banquet hall had a policy of preparing 30% more food than what was required based on the reservations, in order to avoid running out. This practice led to a systematic production of food surplus that consequently caused food waste. Finally, there were instances where the menu selected was not appropriate to a specific event and layout, causing food waste. For example, a very 'heavy' and 'rich' menu comprising curries, stews and rice, was selected for a marketing event where the layout of the dinner aimed to encourage networking amongst participants and as such did not have chairs. Participants could not easily eat the type of food offered without sitting down, which led to substantial buffet leftover waste. 'Finger' food would have been a more appropriate menu for this type of event.

CS2 (*a la carte* Chinese restaurant) had the second lowest avoidable food waste percentage, due to the fact that it only offered *a la carte* service. CS2 had no buffet leftover food waste and food was prepared for the correct number of customers, rather than estimated number of customers such as in the case of the buffet restaurants. Observations revealed that the waiting staff of CS2 had the opportunity to consult customers on the right amount of food to be ordered and explain the items on the menu so that the customers could avoid ordering too much or food they did not like.

CS5 (university canteen) had the lowest avoidable waste percentage and the lowest food waste generation overall, making it overall the least wasteful case study. The meals at CS5 were very affordable compared to the other case studies. The quality and variety of food reflected the low price in CS5, nonetheless the profit margins were considerably lower compared to the other case studies. Interviews with staff and management of the university canteen revealed that the low profit margins were the main driver for using food more efficiently and minimising food waste. The canteen prepared only enough food for the number of customer expected even if that meant that the last customers did not enjoy the same variety as the first (unlike CS1 and CS4 where 30% more food was prepared in order to ensure the buffet never ran out).

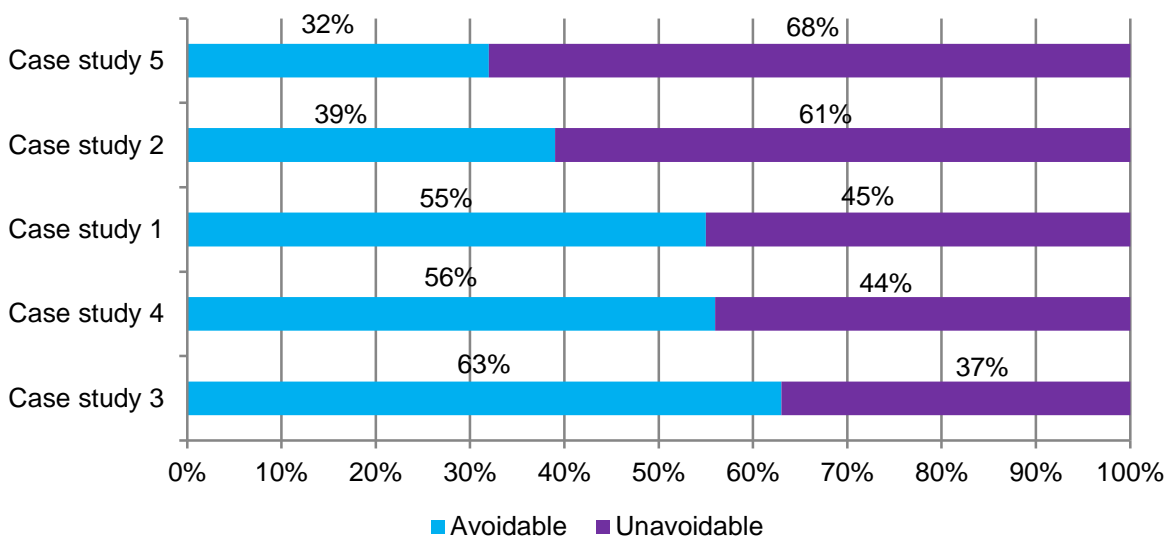


Figure 20: Avoidable and unavoidable food waste fractions

The case studies that wasted more food also had higher percentages of avoidable food waste. The order of the most wasteful case studies was CS4, followed by CS3, CS1, CS2 and finally CS5, as expressed by the food waste per customer rate (Table 9). The order of the highest avoidable food waste percentage was CS3, followed by CS4, CS1, CS2 and finally CS5, almost the same as the order for the food waste generation. The correlation between food waste generation and avoidable waste suggests that the restaurants that ensured avoidable food waste was reduced also practiced food waste prevention overall. The least wasteful (in terms of avoidable food waste and of overall food waste) case studies CS5 and CS2 had one thing in common: the customer paid according to what they ordered and not a flat rate like in the other case studies where 'all you can eat' type of buffet operated. They also avoided food surplus and thus prevented food waste (for the transition of food surplus into food waste see Papargyropoulou et al., 2014). CS1 (banquet hall) practiced some food waste prevention by diverting buffet leftover to CS3 and to their staff's canteen, however they

systematically produced 30% more food than was required, allowed last minute changes to booking details such as numbers of customers and menu, and did not offer suitable menus based on the type of the events and their sitting layouts (see example above). CS4 (hotel restaurant) had a policy to produce 30% more food than was required and a policy stipulating that no food should stay at the buffet for longer than four hours. Both these policies systematically produced food surplus and food waste.

The consumers' expectations of a continuously full buffet with excessive amount of different items on offer was given as the main reason behind the restaurants' practice of producing 30% more food than what was required. Observations of food consumption practices in buffets highlighted the link between food waste generation, in particular customer plate food waste, and the customers' perceptions of 'value for money'. Discussions with customers and staff revealed that the notion of 'value for money' closely related to quantity not necessarily quality of food. Examples illustrating this point include customers taking too much food on their plate, consuming only a small fraction of it, leaving considerable amount of uneaten food on their table, before going back to the buffet to take another plate. This cycle was repeated numerous times. These examples demonstrate how food waste generation was affected by the type of service provided such as 'all you can eat' buffets, the customers' expectations such as the social norm of buffet abundance and food consumption practices such as binge eating (for consumption practices see Sahakian and Wilhite, 2014).

The Mass Flow Analyses for CS1, CS2 and CS4 illustrate that food waste accounted for 16-28% of the total food⁵ (Figure 21, Figure 22, and Figure 23)⁶. The average food waste rate was higher than the average 18% reported by Beretta et al (2013), 20% reported by WRAP (2013) and Engström et al (Engström et al., 2004), however lower than the maximum food waste Beretta et al (2013) encountered during their study, of 45% at a gourmet restaurant. Cereal was the most wasted food commodity across all case studies, followed by fruits and vegetables for the case studies that offered buffets. This result corresponds with WRAP's (2013) study that encountered 40% of all waste was carbohydrates. These patterns can be explained by the fact that the case studies wasted a lot of rice as buffet leftover due to overproduction, and in the form of customer plate waste as rice was perceived as a 'cheap filler' rather than the main course. Fruits and vegetables were the main food commodities in the preparation

⁵ CS3 and CS5 did not provide sufficient data to carry out analysis of the material and economic flows.

⁶ The Material Flow Analyses figures illustrate the total food waste: avoidable and unavoidable.

waste of buffets, especially since they were quite heavy (for example watermelon skins) and were used in high quantities as they were cheaper than meat, fish and seafood.

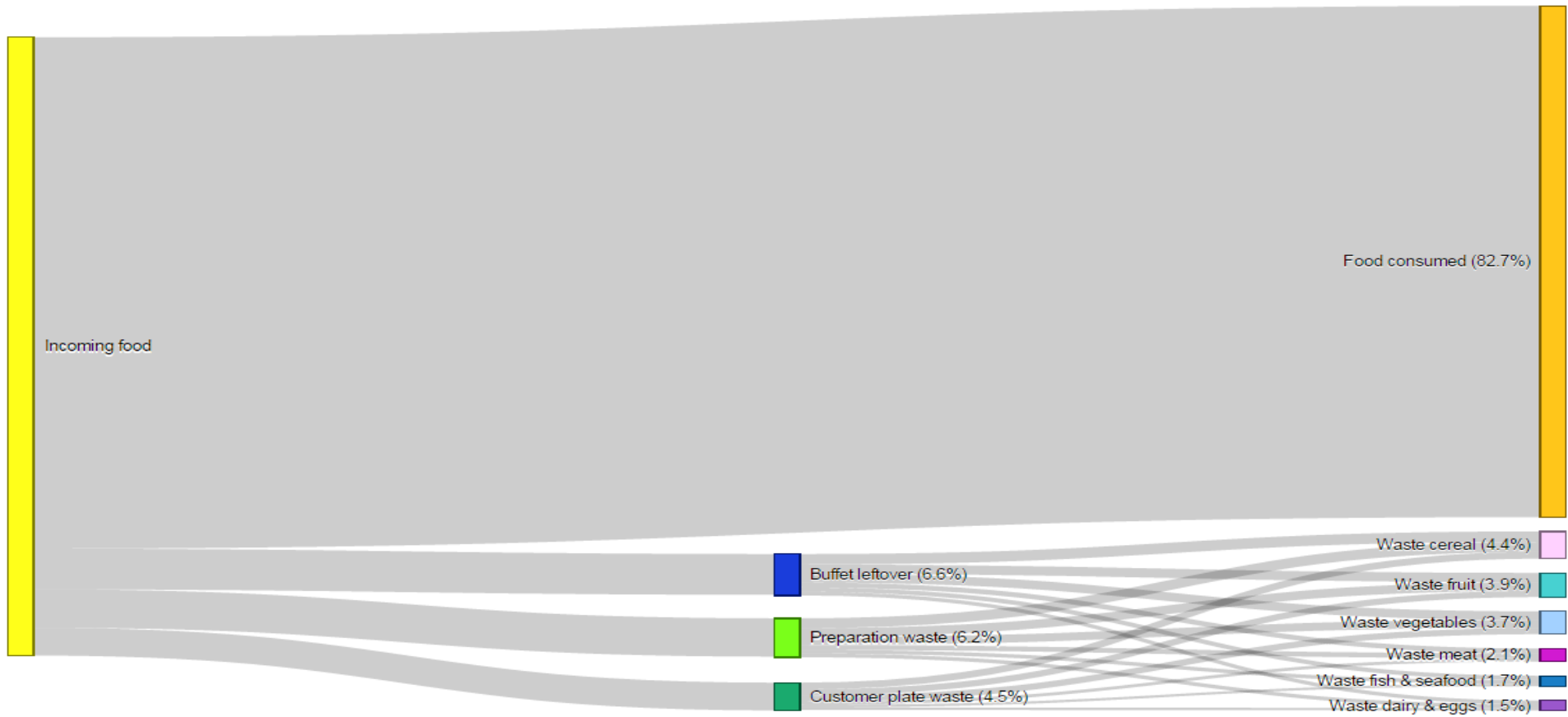


Figure 21: Material Flow Analysis for CS1 (banquet facility). Using software by Bostok (2014)

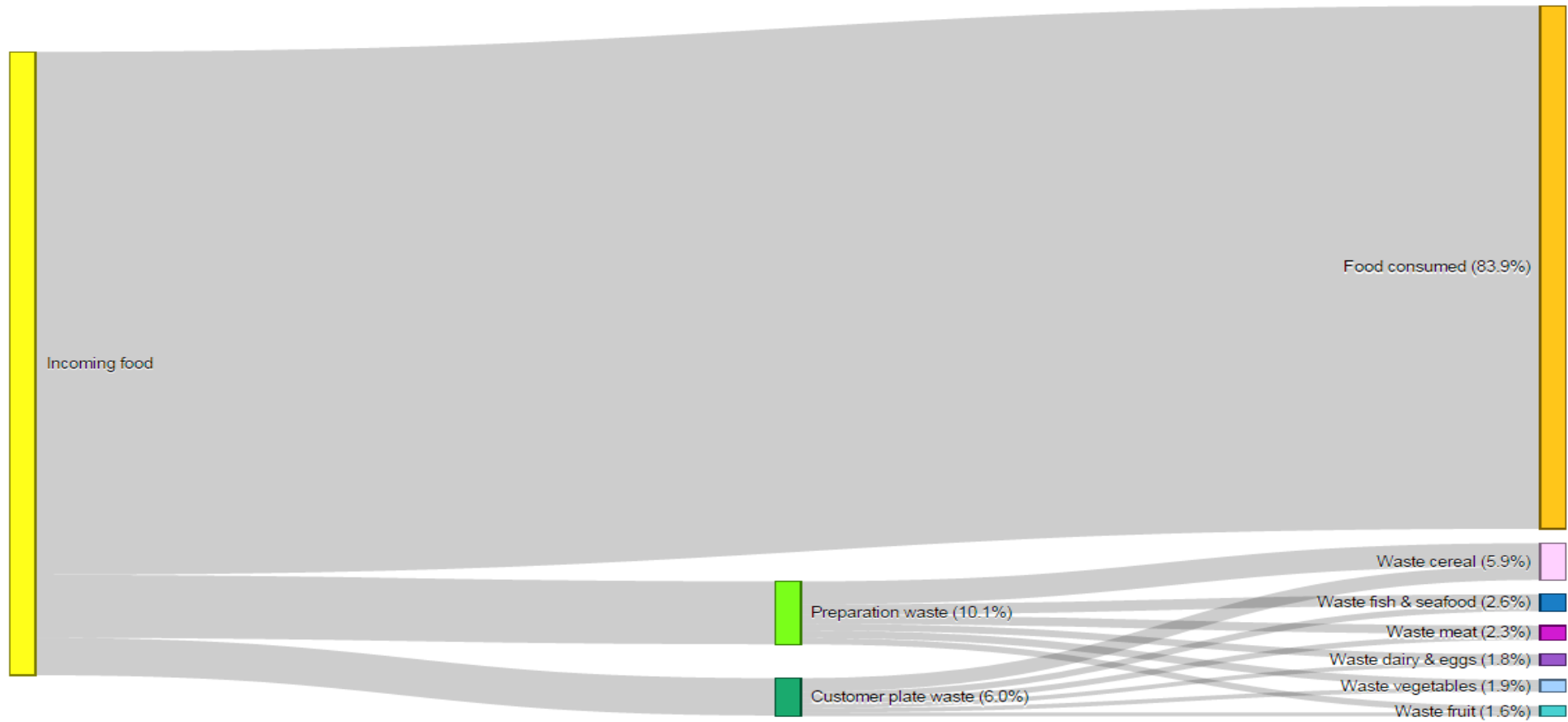


Figure 22: Material Flow Analysis for CS2 (Chinese restaurant). Using software by Bostok (2014)

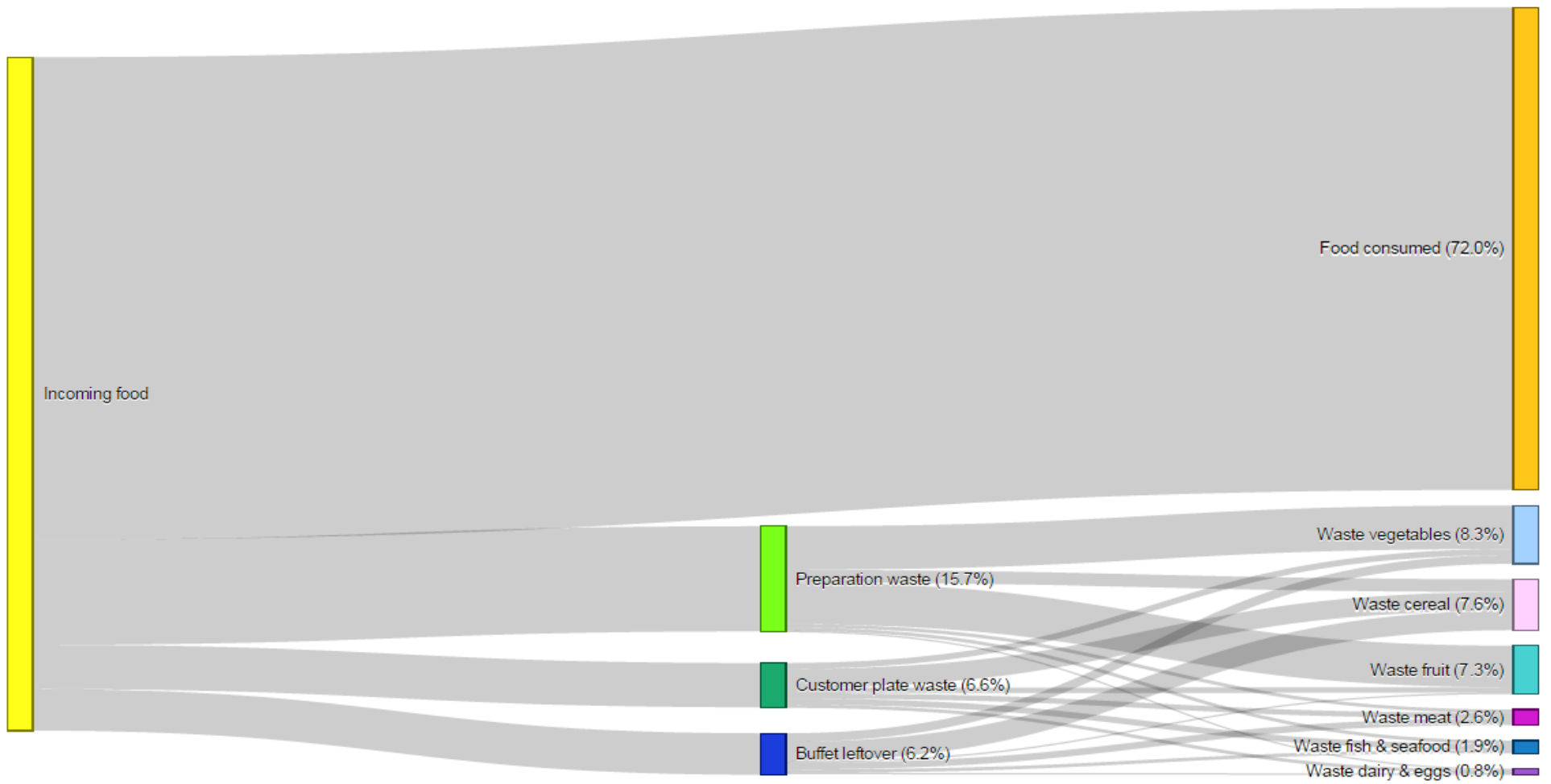


Figure 23: Material Flow Analysis for CS4 (Hotel restaurant).Using the software by Bostok (2014)

Food waste represented an economic loss of 16.4% of the value of the food purchased for CS1 (banquet facility), 16.8% for CS2 (Chinese restaurant) and 31.3% of CS4 (hotel restaurant). These results suggested that although CS1 was more wasteful in terms of mass, it performed better in economic terms than CS2. CS1 wasted more fruits and vegetables, that are cheaper compared to fish, seafood and meat that were wasted in higher quantities in CS2. CS4 had significant losses both in mass and economic terms.

4.5.2 Food waste prevention recommendations

The causes of food waste generation were grouped into two categories depending on whether they were related primarily to food production or consumption. This distinction was made to help provide food waste prevention recommendations tailored to each stage. In food production food waste was generated in a systematic manner. The way the restaurants procured, stored, prepared, cooked, displayed the food and their operating procedures, for example their reservation system, systematically caused food waste generation. During food consumption, the consumers' social practices were the main causes of food waste generation, however the restaurants' operating procedures also led to systematic food waste generation. Recommendations for food waste prevention are presented in Table 10 and Table 11 tailored specifically for preparation, buffet leftover and customer plate waste.

Table 10: Recommendations for food waste prevention addressing systematic food waste generation

Causes of systematic food waste generation	Food waste prevention recommendations	Type of food waste targeted by recommendation
‘All you can eat’ buffets	Opt for a <i>la carte</i> service	Preparation waste Buffet leftover Customer plate waste
	Opt for a ‘pay what you eat’ type of buffet	Customer plate waste
	Introduce a charge if food waste is left on customer’s plate or offer a reward such as a discount, if no food waste is left on the plate	Customer plate waste

Causes of systematic food waste generation	Food waste prevention recommendations	Type of food waste targeted by recommendation
Food surplus generation: policy of preparing 30% more food than what is needed	Prevent food surplus by preparing only what is necessary by improving the demand forecast. This measure can be achieved by improving the reservation system to make accurate predictions of customer numbers (see recommendation below). Have staff on stand-by to prepare extra food if necessary. This measure requires the customers to accept that towards the end of the buffet all dishes might not be available. It also requires that the customer pays according to what they eat, or a type of compensation to the late customers that might not receive the full variety of the buffet, for example a discount for customers arriving half an hour before the buffet closes.	Preparation waste Buffet leftover
Failure of booking system to accurately predict numbers	Improve booking system by confirming numbers the day before. Request a deposit when reservation is made to limit 'no shows'. Implement an 'only by reservation policy' where only customers that have made a reservation are accepted. A softer approach to this measure is to encourage customers to make a reservation by offering a discount. Customers that have no reservation can still dine, however they miss out on that discount.	Preparation waste Buffet leftover

Causes of systematic food waste generation	Food waste prevention recommendations	Type of food waste targeted by recommendation
Food safety policy stipulating that no food should be left on the buffet longer than 4 hours	<p>Instead of having a 'blanket 'policy stipulating a specific number of maximum hours for food to be left on the buffet, have a strategy that works in stages for assessing food safety. Chefs can assess on a case by case basis which dishes are more likely to become unsafe based on their ingredients, cooking and storage method. This way, dishes of higher risk can be removed from the buffet earlier than food items that can last longer.</p> <p>After closure of the buffet direct buffet leftover to staff canteen for immediate consumption. Supervise this process closely to avoid staff eagerly removing buffet items earlier than they should to enjoy them in the staff canteen.</p> <p>Alternatively, redirect buffet leftover that is safe for human consumption to food charities and soup kitchens for immediate consumption. This measure needs to be accompanied by strict food safety guidelines and a no liabilities agreement between the restaurant and the charity. The agreement needs to remove responsibility for food safety from the restaurant as soon as the food leaves its premises.</p> <p>Buffet leftover unfit for human consumption can be diverted to farms to be tuned into animal feed. The animal feed needs to comply with food safety laws to prevent infecting animals with viruses such as Foot and Mouth.</p> <p>Diverting the remaining food waste to composting or energy from waste facilities is the next option for treating unavoidable food waste.</p>	Buffet leftover

Causes of systematic food waste generation	Food waste prevention recommendations	Type of food waste targeted by recommendation
Lack of coordination between departments in restaurant	<p>Improve communication between departments by regular meetings to resolve any conflicts and plan ahead for the daily schedule. In meetings, the latest information should be shared amongst the departments, for example on the items and quantities of food supplies received, the cooking and food preparation schedule and menus, the reservations details including cancellations and last minute changes and feedback from customers and observations by the waiting staff for example which food items are always left on the plate, which buffet dishes need frequent replenishment.</p> <p>Assign food waste prevention champions within each department.</p> <p>Align departmental performance criteria to resolve conflicts between the departments and have common targets. Make food waste reduction one of these targets.</p>	Preparation waste Buffet leftover
Inappropriate menu for eating occasion and sitting layout	In the cases of banquet facilities, train the reservations team to correctly advise the customer on the most appropriate menu for each sitting layout and type of function. Seek feedback from the waiting staff on the menus that work better with certain layouts and functions, based on their observations and customer feedback.	Preparation waste Buffet leftover Customer plate

Causes of systematic food waste generation	Food waste prevention recommendations	Type of food waste targeted by recommendation
Aesthetic standards in the buffet and plate presentation	<p>Avoid elaborate buffet and plate decoration designs where possible.</p> <p>Observe which items remain uneaten on the plates and eliminate them from the plate design. For example, garnishes that do not add flavour to the dishes could be eliminated without compromising the integrity of the dish.</p> <p>Reuse the decorative food items in other dishes. For instance, the watermelon cut into the shape of a flower to decorate the buffet, could be made into a smoothie or a juice to include as a special item for the next sitting.</p>	Preparation waste Buffet leftover
Avoidable preparation food waste due to poor cutting skills	<p>Train kitchen staff on cutting techniques.</p> <p>Observe and reward the best 'cutters' each month.</p> <p>Assign food waste prevention champions in the kitchen.</p>	Preparation waste
	<p>Reduce portion sizes for rice, noodles and local fruits in the <i>a la carte</i> service, but offer the option to add more at no extra charge.</p> <p>Place rice, noodles and fruits at the end of the buffet line.</p>	Customer plate

Table 11: Recommendations for food waste prevention related to food consumption practices

Causes of food waste generation related to food consumption practices	Food waste prevention recommendations	Type of food waste targeted by recommendation
Ordering too much food	<p>Train waiting staff to correctly advice customers on the size and richness of the dishes.</p> <p>Offer smaller portions with the option to add more at no extra charge.</p> <p>Offer a range of dish sizes, such as small, regular, big and special size for children and side dishes.</p> <p>Pack any leftovers and offer them as take away, as a standard practice unless customer instructs otherwise.</p> <p>This measure should be accompanied by simple food safety instructions to the customer, such as 'consume within X hours and do not reheat', and a no liabilities clause for the restaurant for food that has left their premises.</p>	Customer plate
Customer does not like a dish they ordered	Train waiting staff to explain the menu and ingredients to the customers, as well as give advice which dishes complement each other.	Customer plate

Causes of food waste generation related to food consumption practices	Food waste prevention recommendations	Type of food waste targeted by recommendation
Taking too much on plate in 'all you can eat' buffet	<p>Reducing plate size has the potential to reduce food waste without compromising customer satisfaction (Kallbekken and Sælen, 2013).</p> <p>Have restaurant staff stationed by the buffet to serve the food onto the customers' plates and explain the dishes and ingredients.</p> <p>Tray less systems have been proven to reduce plate waste especially in canteen settings (Thiagarajah and Getty, 2013).</p>	Customer plate
Trying out all dishes in 'all you can eat' buffet	Offer the option for customers to taste the dishes as they go around the buffet before deciding whether they like it or not.	Customer plate

Causes of food waste generation related to food consumption practices	Food waste prevention recommendations	Type of food waste targeted by recommendation
Customer's perceived value for money: quantity not quality	<p>Altering the customer's perceptions of value is outside the control and remit of the restaurant. However, promoting the quality of the food rather than the quantity of the items on the buffet is one way of shifting the emphasis and attention of the customer. This can be done through the restaurant's marketing material for example by highlighting the culinary skills of the chefs, the uniqueness of the menu and the quality ingredients rather than just the number of the food items on the buffet. Use 'nudging' techniques to promote food waste reduction, such as displaying signs encouraging customers to come back to the buffet and help themselves more than one time, rather than take a lot of food on their plate all at once (Kallbekken and Sælen, 2013).</p>	<p>Preparation waste Buffet leftover Customer plate</p>
The perceived value of food is linked to the price, for example rice is cheap so it can be wasted	<p>Appoint food waste champions in the kitchen to highlight the importance of food waste prevention across all food groups, not only the expensive ones. Provide posters in the kitchen demonstrating good examples of food waste prevention and bad practices.</p> <p>Provide training in cutting skills to reduce avoidable food waste especially of fruits and vegetables.</p> <p>Update cooking equipment and improve cooking technique to avoid instances whether rice is stuck at the bottom of the pan.</p>	Preparation waste

Causes of food waste generation related to food consumption practices	Food waste prevention recommendations	Type of food waste targeted by recommendation
	<p>Avoid over production of rice, noodles and local fruits (all perceived less valuable due to their comparatively lower price) by reducing how much is prepared per customer in the buffet.</p> <p>Display them in smaller serving dishes rather than in big containers.</p>	Buffet leftover

4.6 Conclusions

Nearly one third of all food was wasted (16-28%) in the hospitality and food service sector case studies presented in this paper, and almost half of it was avoidable (average avoidable food waste across all case studies was 49% of total food waste). Food waste represented a substantial economic loss amounting to approximately 23% of the value of the food purchased. Preparation waste was the largest fraction, followed by buffet leftover and then customer plate waste, challenging the hypothesis that the consumer is to blame for the majority of the food waste. The restaurants' operating procedures and policies led to systematic food waste generation. Social practices related to food consumption were also identified as causes of food waste generation.

This paper provides new empirical evidence to highlight the significant opportunity and scope for food waste reduction in the hospitality and food service sector. By identifying the causes of food waste, strategies for food waste prevention can be developed. Food waste prevention strategies should be twofold, tackling both the way the hospitality and food service sector outlets operate and organise themselves, and the customers' social practices related to food consumption. Food waste prevention measures targeting the systematic food waste production due to the restaurants' operations are within the restaurants' control, whereas changing social practices associated with food consumption is a more complex issue and requires a multifaceted approach. The main actor and implementer of these strategies could be the hospitality and food service sector itself, as innovation and leadership in food waste prevention by the operators has the potential for significant cost savings. National policies and regulations should enable and reward food waste prevention within the food service sector. The hospitality and food service sector associations can also provide support in the form of guidance, tools and training.

Further research is required to expand on this study's findings in different contexts within the hospitality and food service sector, and to test the efficacy of the proposed food waste prevention measures. In this endeavour approaches, methods and tools from a variety of disciplines such as business, management, logistics, economics, environmental and waste management, sociology, psychology, behaviour studies and sustainable consumption should be employed.

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4.8 References

- Abeliotis, K., Lasaridi, K., Costarelli, V. & Chroni, C. (2015). The Implications of Food Waste Generation on Climate Change: The Case of Greece. *Sustainable Production and Consumption*, 3(March), 8–14. Retrieved from <http://dx.doi.org/10.1016/j.spc.2015.06.006>
- Al-Domi, H., Al-Rawajfeh, H., Aboyouisif, F., Yaghi, S., Mashal, R. & Fakhoury, J. (2011). Determining and Addressing Food Plate Waste in a Group of Students at the University of Jordan. *Pakistan Journal of Nutrition*, 10(9), 871–878.
- Alexander, C. & Smaje, C. (2008). Surplus Retail Food Redistribution: An Analysis of a Third Sector Model. *Resources, Conservation and Recycling*, 52(11), 1290–1298.
- Beretta, C., Stoessel, F., Baier, U. & Hellweg, S. (2013). Quantifying Food Losses and the Potential for Reduction in Switzerland. *Waste Management*, 33(3), 764–773. Retrieved from <http://dx.doi.org/10.1016/j.wasman.2012.11.007>
- Bernstad, A. (2014). Household Food Waste Separation Behavior and the Importance of Convenience. *Waste Management*, 34(7), 1317–1323. Retrieved from <http://dx.doi.org/10.1016/j.wasman.2014.03.013>
- Betz, A., Buchli, J., Göbel, C. & Müller, C. (2015). Food Waste in the Swiss Food Service Industry – Magnitude and Potential for Reduction. *Waste Management*, 35, 218–226. Retrieved from <http://dx.doi.org/10.1016/j.wasman.2014.09.015>
- Bolton, L. E. & Alba, J. W. (2012). When Less Is More: Consumer Aversion to Unused Utility. *Journal of Consumer Psychology*, 22(3), 369–383. Retrieved from <http://dx.doi.org/10.1016/j.jcps.2011.09.002>
- Buzby, J. C. & Hyman, J. (2012). Total and per Capita Value of Food Loss in the United States. *Food Policy*, 37, 561–570. Retrieved from <http://dx.doi.org/10.1016/j.foodpol.2012.06.002>
- Chen, H., Jiang, W., Yang, Y., Yang, Y. & Man, X. (2016). State of the Art on Food Waste Research: A Bibliometrics Study from 1997 to 2014. *Journal of Cleaner Production*. Retrieved from <http://www.sciencedirect.com/science/article/pii/S095965261501803X>
- Cicatiello, C., Franco, S., Pancino, B. & Blasi, E. (2016). The Value of Food Waste: An Exploratory Study on Retailing. *Journal of Retailing and Consumer Services*, 30, 96–104. Retrieved from <http://linkinghub.elsevier.com/retrieve/pii/S0969698916300078>

- Collins, P. A., Power, E. M. & Little, M. H. (2014). Municipal-Level Responses to Household Food Insecurity in Canada: A Call for Critical, Evaluative Research. *Canadian Journal of Public Health*, 105(2).
- Dias-Ferreira, C., Santos, T. & Oliveira, V. (2015). Hospital Food Waste and Environmental and Economic Indicators - A Portuguese Case Study. *Waste Management*, 46, 146–154. Retrieved from <http://dx.doi.org/10.1016/j.wasman.2015.09.025>
- 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. *Global Food Security*, 8, 19–26. Retrieved from <http://linkinghub.elsevier.com/retrieve/pii/S2211912415300195>
- Edwards, F. & Mercer, D. (2007). Gleaning from Gluttony: An Australian Youth Subculture Confronts the Ethics of Waste. *Australian Geographer*, 38(3), 279–296. Retrieved July 4, 2012, from <http://www.tandfonline.com/doi/abs/10.1080/00049180701639174>
- Engström, R., Carlsson-Kanyama, A., Engströma, R. & Carlsson-Kanyamab, A. (2004). Food Losses in Food Service Institutions Examples from Sweden. *Food Policy*, 29(3), 203–213. Retrieved April 3, 2012, from <http://linkinghub.elsevier.com/retrieve/pii/S030691920400020X>
- Evans, D. (2011). Blaming the Consumer – Once Again: The Social and Material Contexts of Everyday Food Waste Practices in Some English Households. *Critical Public Health*, 21(4), 429–440.
- Evans, D. (2014). *Food Waste. Home Consumption, Material Culture and Everyday Life*. London: Bloomsbury Academic.
- Evans, D., Campbell, H. & Murcott, A. (2013). *Waste Matters: New Perspectives on Food and Society* (D. Evans, H. Campbell, and A. Murcott, Eds.). Oxford: Wiley-Blackwell/ The Sociological Review.
- FAO. (2015). Global Initiative on Food Loss and Food Waste Reduction. Retrieved from <http://www.fao.org/save-food/en/>
- Garnett, T. (2011). Where Are the Best Opportunities for Reducing Greenhouse Gas Emissions in the Food System (Including the Food Chain)? *Food Policy*, 36, S23–S32. Retrieved September 23, 2013, from <http://linkinghub.elsevier.com/retrieve/pii/S0306919210001132>

- Garnett, T. (2014). Three Perspectives on Sustainable Food Security: Efficiency, Demand Restraint, Food System Transformation. What Role for Life Cycle Assessment? *Journal of Cleaner Production*, 73, 10–18. Retrieved from <http://dx.doi.org/10.1016/j.jclepro.2013.07.045>
- Garrone, P., Melacini, M. & Perego, A. (2014). Opening the Black Box of Food Waste Reduction. *Food Policy*, 46, 129–139. Retrieved from <http://dx.doi.org/10.1016/j.foodpol.2014.03.014>
- Giroto, F., Alibardi, L. & Cossu, R. (2015). Food Waste Generation and Industrial Uses: A Review. *Waste Management*, 45, 32–41. Retrieved from <http://dx.doi.org/10.1016/j.wasman.2015.06.008>
- Goonan, S., Miroso, M. & Spence, H. (2014). Getting a Taste for Food Waste: A Mixed Methods Ethnographic Study into Hospital Food Waste before Patient Consumption Conducted at Three New Zealand Foodservice Facilities. *Journal of the Academy of Nutrition and Dietetics*, 114(1), 63–71. Retrieved from <http://dx.doi.org/10.1016/j.jand.2013.09.022>
- Gustavsson, J., Cederberg, C., Sonesson, U., Otterdijk, R. van & Meybeck, A. (2011). *Global Food Losses and Food Waste. Extent, Causes and Prevention*. Rome.
- Halloran, A., Clement, J., Kornum, N., Bucatariu, C. & Magid, J. (2014). Addressing Food Waste Reduction in Denmark. *Food Policy*, 49(P1), 294–301.
- Herszenhorn, E., Quested, T., Eastal, S., Prowse, G., Lomax, J. & Bucatariu, C. (2014). *Prevention and Reduction of Food and Drink Waste in Businesses and Households: Guidance for Governments, Local Authorities, Businesses and Other Organisations*.
- Kallbekken, S. & Sælen, H. (2013). “Nudging” Hotel Guests to Reduce Food Waste as a Win-Win Environmental Measure. *Economics Letters*, 119(3), 325–327. Retrieved from <http://dx.doi.org/10.1016/j.econlet.2013.03.019>
- Katajajuuri, J. M., Silvennoinen, K., Hartikainen, H., Heikkilä, L. & Reinikainen, A. (2014). Food Waste in the Finnish Food Chain. *Journal of Cleaner Production*, 73, 322–329. Retrieved from <http://dx.doi.org/10.1016/j.jclepro.2013.12.057>
- 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. *Science of the Total Environment*, 438, 477–489. Retrieved from <http://dx.doi.org/10.1016/j.scitotenv.2012.08.092>

- Lazell, J. (2016). Consumer Food Waste Behaviour in Universities: Sharing as a Means of Prevention. *Journal of Consumer Behaviour*. Retrieved from doi: 10.1002/cb.1581
- Lebersorger, S. & Schneider, F. (2014). Food Loss Rates at the Food Retail, Influencing Factors and Reasons as a Basis for Waste Prevention Measures. *Waste Management*, 34(11), 1911–1919. Retrieved from <http://dx.doi.org/10.1016/j.wasman.2014.06.013>
- Leray, L., Sahakian, M. & Erkman, S. (2016). Understanding Household Food Metabolism: Relating Micro-Level Material Flow Analysis to Consumption Practices. *Journal of Cleaner Production*.
- 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. Retrieved from <http://dx.doi.org/10.1016/j.appet.2016.03.017>
- Maniates, M. F. (2001). Individualization: Plant a Tree, Buy a Bike, Save the World? *Global Environmental Politics*, 1(3), 31–52.
- Mena, C., Adenso-Diaz, B. & Yurt, O. (2011). The Causes of Food Waste in the Supplier-Retailer Interface: Evidences from the UK and Spain. *Resources, Conservation and Recycling*, 55(6), 648–658. Retrieved from <http://dx.doi.org/10.1016/j.resconrec.2010.09.006>
- Midgley, J. L. (2013). The Logics of Surplus Food Redistribution. *Journal of Environmental Planning and Management*, (March 2015), 1–21. Retrieved from <http://www.tandfonline.com/doi/abs/10.1080/09640568.2013.848192>
- Miliute-Plepiene, J. & Plepys, A. (2014). Does Food Sorting Prevents and Improves Sorting of Household Waste? A Case in Sweden. *Journal of Cleaner Production*, 101, 182–192. Retrieved from <http://dx.doi.org/10.1016/j.jclepro.2015.04.013>
- Nahman, A. & de Lange, W. (2013). Costs of Food Waste along the Value Chain: Evidence from South Africa. *Waste Management*, 33(11), 2493–2500. Retrieved from <http://dx.doi.org/10.1016/j.wasman.2013.07.012>
- Padfield, R., Papargyropoulou, E. & Preece, C. (2012). A Preliminary Assessment of Greenhouse Gas Emission Trends in the Production and Consumption of Food in Malaysia. *International Journal of Technology*, 3(1), 56–66.
- Padfield, R., Tham, M. H., Costes, S. & Smith, L. (2016). Uneven Development and the Commercialisation of Public Utilities: A Political Ecology Analysis of Water

Reforms in Malaysia. Utilities Policy.

- Padfield, R., Waldron, S., Drew, S., Papargyropoulou, E., Kumaran, S., Page, S., et al. (2015). Research Agendas for the Sustainable Management of Tropical Peatland in Malaysia. *Environmental Conservation*, 42(1), 73–83.
- Papargyropoulou, E. (2012). Food Consumption and Waste in Case Study 1. Malaysia: Unpublished photograph.
- Papargyropoulou, E. (2014). Food Preparation and Waste in Case Study 4. Malaysia: Unpublished photograph.
- Papargyropoulou, E., Colenbrander, S., Sudmant, A. H., Gouldson, A. & Tin, L. C. (2015). The Economic Case for Low Carbon Waste Management in Rapidly Growing Cities in the Developing World: The Case of Palembang, Indonesia. *Journal of Environmental Management*, 163, 11–19. Retrieved from <http://linkinghub.elsevier.com/retrieve/pii/S030147971530205X>
- Papargyropoulou, E., Lozano, R., K. Steinberger, J., Wright, N. & Ujang, Z. Bin. (2014). The Food Waste Hierarchy as a Framework for the Management of Food Surplus and Food Waste. *Journal of Cleaner Production*, 76, 106–115. Retrieved May 28, 2014, from <http://linkinghub.elsevier.com/retrieve/pii/S0959652614003680>
- 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 Management*, 49(March), 326–336. Retrieved from <http://linkinghub.elsevier.com/retrieve/pii/S0956053X16300174>
- Parfitt, J., Barthel, M. & Macnaughton, S. (2010). Food Waste within Food Supply Chains: Quantification and Potential for Change to 2050. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, 365(1554), 3065–81. Retrieved March 9, 2012, from <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2935112&tool=pmcentrez&rendertype=abstract>
- 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 Management*, 35, 207–217. Retrieved from <http://dx.doi.org/10.1016/j.wasman.2014.09.019>
- Pirani, S. I. & Arafat, H. (2015). Reduction of Food Waste Generation in the Hospitality Industry. *Journal of Cleaner Production*. Retrieved from

<http://linkinghub.elsevier.com/retrieve/pii/S095965261501077X>

- Richter, B. & Bokelmann, W. (2016). Approaches of the German Food Industry for Addressing the Issue of Food Losses. *Waste Management*, 48, 423–429. Retrieved from <http://dx.doi.org/10.1016/j.wasman.2015.11.039>
- Rispo, A., Williams, I. D. & Shaw, P. J. (2015). Source Segregation and Food Waste Prevention Activities in High-Density Households in a Deprived Urban Area. *Waste Management*, 44, 15–27. Retrieved from <http://linkinghub.elsevier.com/retrieve/pii/S0956053X15002822>
- Sahakian, M. & Wilhite, H. (2014). Making Practice Theory Practicable: Towards More Sustainable Forms of Consumption. *Journal of Consumer Culture*, 14, 25–44. Retrieved from <http://joc.sagepub.com/cgi/content/long/14/1/25%5Cnhttp://joc.sagepub.com/cgi/doi/10.1177/1469540513505607>
- Schneider, F. (2013). The Evolution of Food Donation with Respect to Waste Prevention. *Waste Management*, 33(3), 755–763. Retrieved from <http://dx.doi.org/10.1016/j.wasman.2012.10.025>
- Scholz, K., Eriksson, M. & Strid, I. (2014). Carbon Footprint of Supermarket Food Waste. *Resources, Conservation and Recycling*, 94, 56–65. Retrieved from <http://dx.doi.org/10.1016/j.resconrec.2014.11.016>
- Secondi, L., Principato, L. & Laureti, T. (2015). Household Food Waste Behaviour in EU-27 Countries: A Multilevel Analysis. *Food Policy*, 56, 25–40. Retrieved from <http://www.sciencedirect.com/science/article/pii/S0306919215000858>
- Shove, E. (2010). Beyond the ABC: Climate Change Policy and Theories of Social Change. *Environment and Planning A*, 42(6), 1273–1285. Retrieved from <http://www.envplan.com/abstract.cgi?id=a42282>
- Silvennoinen, K., Heikkil, L., Katajajuuri, J. M. & Reinikainen, A. (2015). Food Waste Volume and Origin: Case Studies in the Finnish Food Service Sector. *Waste Management*, 46, 140–145. Retrieved from <http://dx.doi.org/10.1016/j.wasman.2015.09.010>
- Song, G., Li, M., Semakula, H. M. & Zhang, S. (2015). Food Consumption and Waste and the Embedded Carbon, Water and Ecological Footprints of Households in China. *Science of the Total Environment*, 529, 191–197. Retrieved from <http://dx.doi.org/10.1016/j.scitotenv.2015.05.068>

- Sonnino, R. & McWilliam, S. (2011). Food Waste, Catering Practices and Public Procurement: A Case Study of Hospital Food Systems in Wales. *Food Policy*, 36(6), 823–829. Retrieved from <http://dx.doi.org/10.1016/j.foodpol.2011.09.003>
- Stancu, V., Haugaard, P. & Lähteenmäki, L. (2016). Determinants of Consumer Food Waste Behaviour: Two Routes to Food Waste. *Appetite*, 96, 7–17.
- Stefan, V., van Herpen, E., Tudoran, A. A. & Lähteenmäki, L. (2013). Avoiding Food Waste by Romanian Consumers: The Importance of Planning and Shopping Routines. *Food Quality and Preference*, 28(1), 375–381. Retrieved from <http://dx.doi.org/10.1016/j.foodqual.2012.11.001>
- Sustainable Restaurant Association. (2010). *Too Good to Waste*. Restaurant Food Waste Survey Report. London.
- Thi, N. B. D., Kumar, G. & Lin, C.-Y. (2015). An Overview of Food Waste Management in Developing Countries: Current Status and Future Perspective. *Journal of Environmental Management*, 157, 220–229. Retrieved from <http://www.sciencedirect.com/science/article/pii/S0301479715300256>
- Thiagarajah, K. & Getty, V. M. (2013). Impact on Plate Waste of Switching from a Tray to a Trayless Delivery System in a University Dining Hall and Employee Response to the Switch. *Journal of the Academy of Nutrition and Dietetics*, 113(1), 141–145. Retrieved from <http://dx.doi.org/10.1016/j.jand.2012.07.004>
- Thyberg, K. L. & Tonjes, D. J. (2016). Drivers of Food Waste and Their Implications for Sustainable Policy Development. *Resources, Conservation and Recycling*, 106, 110–123. Retrieved from <http://dx.doi.org/10.1016/j.resconrec.2015.11.016>
- United Nations. (2015). *Transforming Our World: The 2030 Agenda for Sustainable Development*.
- Visschers, V. H. 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. *Journal of Environmental Psychology*, 45, 66–78. Retrieved from <http://dx.doi.org/10.1016/j.jenvp.2015.11.007>
- Warshawsky, D. N. (2015). The Devolution of Urban Food Waste Governance: Case Study of Food Rescue in Los Angeles. *Cities*, 49, 26–34. Retrieved from <http://www.sciencedirect.com/science/article/pii/S0264275115000931>
- Whitehair, K. J., Shanklin, C. W. & Brannon, L. A. (2013). Written Messages Improve Edible Food Waste Behaviors in a University Dining Facility. *Journal of the*

Academy of Nutrition and Dietetics, 113(1), 63–69. Retrieved from
<http://dx.doi.org/10.1016/j.jand.2012.09.015>

Williams, P. & Walton, K. (2011). Plate Waste in Hospitals and Strategies for Change. *e-SPEN*, 6(6), e235–e241. Retrieved from
<http://dx.doi.org/10.1016/j.eclnm.2011.09.006>

WRAP. (2011). *Food Waste in Schools*. Banbury.

WRAP. (2013). *Overview of Waste in the UK Hospitality and Food Service Sector*. Banbury.

Chapter 5: Synthesis and Conclusion

This chapter presents a synthesis of the three papers forming the core of this thesis and the main conclusions drawn from the research underpinning them. The implications of the research, the academic fields it contributes to and its relevance to sustainability research, and recommendations for future research are also discussed.

5.1 Synthesis: A short summary

This thesis aimed at understanding food waste generation in the hospitality and food service sector to identify the most promising opportunities for food waste prevention. This aim was achieved through four research objectives (Figure 24). Firstly, the current framing of food waste in academic and policy literature was critically reviewed and its limitations were identified. This critique led to the development of the Food Waste Hierarchy, a framework for the management of food surplus and food waste. Secondly, a new approach for investigating food waste was developed, and captured in the mixed methods framework for the study of food waste generation and prevention in the hospitality and food service sector. Thirdly, the scale, origin, patterns and causes of food waste generation in the hospitality and food service sector were established and reflected upon critically to provide recommendations for food waste prevention.

Research Aim	Understand why, how, how much and by whom food waste is generated in the hospitality and food service sector in Kuala Lumpur, Malaysia, and identify the most promising opportunities for food waste prevention			
Research Objectives	To reframe food waste to address the weaknesses of contemporary conceptual frameworks	To critique methodological approaches to food waste and develop new framework to study food waste	To investigate food waste generation: scale, origin, patterns, causes	To propose food waste prevention measures

Figure 24: Revisiting research aim and objectives

5.2 Conclusions

Conclusions from the individual papers are presented in Chapters 2, 3 and 4. This section aims to connect these conclusions and reflect on their implications for food waste, and more broadly sustainable production and consumption. The section is structured around the three pillars of this research dealing with how food waste is (currently) and could be (in the future) framed, studied and addressed.

5.2.1 Framing food waste

Conclusion 1: Food waste is not a waste management issue; it is a food production and consumption issue.

Food waste has so far been framed as a waste management problem by mainstream policy and academic literature. This is problematic because the way an issue is framed determines the way it is dealt with. In academic literature food waste has been viewed predominately from an engineering and technological perspective (Chen et al., 2016). Much of research focuses on waste treatment and energy recovery technologies such as anaerobic digestion and composting, and valorisation of food waste⁷ to valuable end-products using green technologies (Luque and Clark, 2013). These approaches are offered as solutions to the global food waste problem, while ignoring that food waste is not just an issue of lost natural resources and economic value, but one with ethical, social and political implications. Food waste valorisation is presented as the sustainable alternative to disposal in a landfill, and as a way to give back value to otherwise worthless discarded materials (Ki Lin et al., 2014). The focus on technological solutions distracts from the causes and processes that systematically give rise to food losses and waste. These losses and waste cause the global food system to become inefficient (one third of food produced is lost or wasted Gustavsson et al., 2011), unequal (795 million people are undernourished FAO et al., 2015), and damaging to the environment (food accounts for 31% of the EU-25's total GHG impacts European Commission, 2006).

Although technological solutions are needed to treat unavoidable food waste, and can make the food system more sustainable to some extent, they cannot offer an all-encompassing quick fix to the food waste challenge. Sustainable production and consumption provides a more holistic perspective to food waste and situates it back within the food debates, rather than a standalone issue. It allows the consideration of food waste within the whole food production and consumption chain, from agriculture, to food processing, to distribution and retail, and finally consumption and disposal. Most importantly, SCP attempts to connect these stages and examine the complex relationships between them. One of the contributions of this research, the Food Waste

⁷ The term 'waste valorisation' refers to any industrial process aimed at reusing, recycling, or composting of wastes into useful products, or sources of energy. It can take the form of one of the following activities: processing of residue or by-products into raw materials, use of discarded finished products as raw materials or energy sources, use of waste materials in manufacturing process stages, and addition of waste materials to finished products (Kabongo, 2013).

Hierarchy aims to reframe food waste. Although the Food Waste Hierarchy emerges primary from the waste management field, it reacts to this field by proposing an SCP perspective to food waste framing.

5.2.2 Studying food waste

Conclusion 2: Less engineering, more social science: Understanding the conduits of food waste generation is the utmost priority in addressing the food waste challenge.

Following on from the previous conclusion, food waste has traditionally been approached from an engineering, technological perspective. It is not surprising that mostly quantitative methods have been used so far to study food waste (with some noteworthy exceptions mentioned in Sections 3.3 and 4.3). In the pursuit of understanding food waste, efforts have been made to quantify it and measure its physical parameters; however, understanding food waste does not exclusively mean measuring it. Understanding the scale of food waste and its physical parameters are very important and necessary aspects of food waste research, especially when aiming to identify priority areas to focus on and design waste management solutions. However, as shown by this research, quantitative methods alone offered limited insights into why, how and by whom food waste was generated in the restaurants studied (see Section 4.5.1). Understanding the conduits of food waste generation is crucial for food waste prevention. Understanding why food waste is generated and who is responsible for it, can help identify ways to prevent it. In this pursuit, qualitative methods of research are very useful. Participant observation, interviews, focus groups, and ethnography traditionally used in sociology offer opportunities to explore the questions of why, how and by whom food waste is generated. This research drew inspiration from sociological perspectives in food waste research that have yielded very insightful findings around those questions, such as in works by Evans (2014; 2011b; 2013), Hawkins (2006) and Alexander (2008; 2013) to name a few. When investigating food waste at an organisational level such as within a restaurant, an office, a school or a hospital for example, the way this organisation operates is also important to food waste generation. Qualitative food waste research examining the role of organisations such as the work of Goonan et al (2014), Midgley (2013), and Young et al (2015) are also very valuable in understanding the processes that give rise to food waste.

Conclusion 3: Mixed methods approaches are needed to connect the biophysical properties of food waste to the social practices of food provisioning and consumption.

As a complex global challenge, food waste requires innovative, flexible and case specific multidisciplinary and interdisciplinary approaches, methods and tools to study it. As this research demonstrated, just applying both quantitative and qualitative methods is not sufficient; these approaches need to be integrated (see section 3.5). Tightly interweaving these methodological approaches is needed to link the biophysical and economic flows of food provisioning and waste generation, with the social and cultural practices associated with food provisioning, preparation and consumption. In reality, during this research the qualitative and quantitative methodological approaches interacted and influenced each other, just as the biophysical properties of food and food waste interacted and influenced the social practices of food provisioning and consumption and vice versa.

However, even with the rise of food waste research and the emergence of perspectives from fields outside that of waste management, there is still not much integration or exchange between quantitative and qualitative approaches. This dichotomy is problematic because it does not allow for a comprehensive investigation of food waste. As this research demonstrates, food waste is intrinsically connected to food consumption, and as such needs to be studied alongside it, not in isolation. The mixed methods conceptual framework for studying food waste developed and applied in this research can achieve this integration (see Chapter 3).

5.2.3 Addressing food waste

Conclusion 4: Causes of food waste are structural rather than behavioural.

Most food waste was generated due to the way the restaurants operated in this study. The majority of food waste was in the form of preparation and buffet leftover waste, whereas customer plate food waste, which was more closely linked to individual customer behaviour, was the smallest fraction (Section 4.5). These findings suggest that the causes of food waste are structural and systematic (namely the policies, procedures and working methods of the restaurants). This conclusion is in line with literature questioning the dominant rhetoric which places the responsibility for environmental degradation and onus for action to the individual (See Maniates, 2001; Shove, 2010; Evans, 2011a). In the case studies examined in this research the consumer is not entirely free of responsibility for their choices that lead to food waste (see example of over-ordering and 'binge eating' practices discussed in Sections 3.5 and 4.5). However, the customers operate within a system that firstly encourages and promotes excessive consumption, such as all-you-can-eat buffets, and secondly makes a profit from it (economies of scale meant that buffets were more profitable than 'a la carte' service in the restaurants examined). The perceptions of the restaurants'

managers and employees also reflected the dominance of this paradigm; it was assumed that customer plate food waste was the most significant contributor of food waste, and as such the customer was to blame for food waste.

The conclusion that the main food waste causes in the hospitality and food service sector are structural is promising for food waste prevention. It suggests that the necessary food waste prevention measures are within the restaurants' control and remit (see Section 4.5.2) and therefore can be more easily implemented than behavioural change in individuals which has been shown to be complex and challenging (Southerton et al., 2011; Scott et al., 2015; Young et al., 2010).

Conclusion 5: Food waste prevention in the hospitality and food service sector has significant potential.

Nearly one third of food was wasted (16-28%) in the hospitality and food service sector case studies examined (see Chapter 4). This represented an economic loss of 23% of the value of the food purchased. Nearly half (49%) of this food waste could have been avoided. The restaurants' procedures and policies were the primary causes for this systematic food waste generation, which suggests that food waste prevention interventions are within the restaurants' control and remit. These findings highlight the significant opportunity food waste prevention offers to this sector (see recommendations in Section 4.5.2). Preventing food waste has the potential not only to improve the environmental and sustainability performance of these restaurants, but it also offers significant cost savings, thus making a compelling business case for such an intervention. It is therefore imperative to highlight the importance of the hospitality and food service sector in food waste prevention policies and to support industry led initiatives such as those by the Sustainable Restaurant Association in providing the necessary guidance and tools to the sector.

Conclusion 6: Reducing food surplus is the best way to tackle food waste.

The Food Waste Hierarchy (see Chapter 2) suggests that food waste prevention is the most advantageous option for tackling food waste because it can reduce food waste's economic, environmental and social impacts more significantly than other options such as reuse, composting or waste treatment with energy recovery. In addition, empirical data from the case studies investigated, identified oversupply as one of the most significant causes of food waste in the hospitality and food service sector, especially in buffets. These findings support Stuart's argument that food surplus is food produced beyond our nutritional needs, and waste is a product of food surplus (2009). Avoiding food surplus production in the first place, therefore can achieve food waste prevention.

Food surplus reduction can be achieved by better matching supply and demand in the hospitality and food service sector (see recommendations in Section 4.5.2).

In order to prevent food waste, the current myth that food surplus is a *necessity* needs to be challenged (see testimonies of restaurant managers claiming a 30% oversupply of food is necessary in Sections 3.5.2 and 4.5.1). Examples of wasting food exist since 12,000 years ago and food surplus has been the foundation of human success for over 10,000 years (Stuart, 2009). However, it is important to distinguish between food surplus that is essential for food security and the undesirable food surplus stemming from human wastefulness and modern consumer culture.

5.3 Contribution and relevance to the field of sustainability research

This research makes four main contributions. Firstly, it contributes much needed empirical data on the scale, nature, patterns and causes of food waste generation in the hospitality and food service sector. It reveals that the scale of the food waste problem in the sector is even greater than previously thought, although there are significant opportunities for food waste prevention. Secondly, it offers recommendations for food waste prevention tailored to the hospitality and food service sector. These recommendations target specific processes and stages of food waste generation that require a range of different interventions tackling both structural and behavioural causes of food waste. These two contributions emerge from and react to the field of waste management. They react by diverting the focus of the waste management field away from engineering and technical approaches, towards concepts and tools from the field of sustainability research such as the circular economy and resource efficiency. In addition, they draw attention to the process of food waste generation to address the root causes of it, rather than favour technical measures for reactive environmental protection, also referred to as end-of-pipe solutions.

On a conceptual level, this research contributes the reframing of food waste through the Food Waste Hierarchy, and the mixed methods conceptual framework for studying food waste in the hospitality and food service sector (third and fourth contributions of the research respectively). These contributions are relevant to the sustainable consumption and production, and broader ecological modernisation discussions. However, this research does not adhere to the dichotomy evident in the SCP debates (for a critical appraisal of SCP debates see Geels et al., 2015). It does not advocate comprehensive transformation of societal structures shaping production and consumption, such as capitalism, materialism, and consumerism, also known as the 'revolutionary SCP position' (Geels et al., 2015). Nor does it suggest that only incremental changes in production and consumption, and technological fixes that

improve efficiency can address the complex environmental challenges we are facing today, known as the 'reformist SCP position' (Geels et al., 2015). The former approach focuses too much on macro structures and can be considered utopian, and the latter places too much emphasis on individual responsibility and lacks ambition. Instead, this research aligns itself with what Geels *et al.* call the 'reconfiguration' position (2015): a middle ground between approaches that focus on macro-contexts such as the nature of capitalism, nature-society interactions, and modernity, and approaches that focus on individuals' choices, attitudes, and motivations. Considering the 'reconfiguration' position within the food waste context, this research proposes to combine more radical recommendations, such as food surplus avoidance, with more mainstream suggestions, such as improved eco- efficiency in food production. In line with Urry (2010), this research suggests that the proposed middle ground position can be achieved with transformation of both the socio-technical *systems* and the daily social *practices* related to food production and consumption.

This message, calling for change in both socio-technical systems and social practices is relevant to the broader sustainability research. It is particularly pertinent not only to the food domain but also to mobility and energy, which combined are responsible for 70–80 per cent of lifecycle environmental impacts in industrialised countries (Tukker et al., 2010). Mobility and energy have similarities with the food domain insofar as they operate within socio-technical systems and they involve individual consumption choices informed by social practices. For this reason, the mixed methods approach and the interdisciplinary nature of the methods applied in this research are also relevant to these sectors. Research in these sectors could gain useful insights by critically reflecting on and attempting to rethink the way energy and mobility are framed, and by applying methods and approaches from disciplines not traditionally used in these sectors, much like this research did for food waste.

5.3.1 *Non-academic contribution*

The primary purpose of this research was to make an original contribution to knowledge. In addition, it made significant contributions to the stakeholders involved in this research, namely the Malaysian food waste policy makers and the hospitality and food service sector establishments representing the five case studies. Following the completion of the research, the Department of Solid Waste Management within the Malaysian Ministry of Housing and Local Government received a non-technical report outlining the key findings of the research and policy recommendations that have the potential to encourage food waste prevention in the country. A copy of the report is presented in Appendix A: Report on food waste minimisation policy options for Malaysia. Relevant research findings were also disseminated to the hospitality and

food service sector establishments that participated in the research. An example report is presented in Appendix B: Food waste minimisation report for case study 4. All references to individuals and organisations have been removed from these reports for confidentiality and anonymity reasons.

5.4 Critique of this research

Whilst considering the contributions of this research, it is also important to critically reflect on its limitations. Threats to validity and reliability, and ways to address them were previously considered in Sections 1.4.3 and 2.5.3. In this section, limitations both in terms of the research design and its scope are discussed. The research design underpinning this research successfully linked quantitative and qualitative aspects of the food waste problem by using an interdisciplinary approach, however its most important limitation was regarding scale and, in particular, connecting the different scales where the food waste problem exists. This research managed to connect the micro level and the meso level of the food waste problem (individual consumption and organisational level respectively). However, although the macro level, for example global food security, the entire food supply chain, the global, regional and national food policy, were acknowledged in this research, they were not explicitly linked to the micro level. Methodologically, this is a challenging task, one that a food systems approach could help tackle (for applications of the food systems approach refer to Ingram, 2011).

There were also limitations in the scope of the research. Although this research was not apolitical in nature, political dimensions such as power were not central in this research framework. Who has access to key resources and capital, who has decision making authority, what are the governing structures at the various organisational, institutional, regional and global levels, are questions that this research did not focus on. Explicitly acknowledging the role of power in complex systems can enhance our understanding of its origins and behaviour and lead to improved policy and institutional design (Sova et al., 2014). Although the importance of the cultural context in food waste generation was highlighted, cultural dimensions were not fully explored because they were outside the scope of this research. The role culture plays in food consumption and waste generation and how could this study be replicated in different cultural contexts, are questions this research did not explicitly address. A political and cultural ecology perspective on the food waste problem could offer important insights particularly relevant to food waste prevention policy (for political ecology refer to Peet et al., 2011; Blaikie, 1985).

5.5 Future research directions

Building on the insights emerging from this research three key areas are recommended for further investigation across different levels: organisational, city or country, and global level.

5.5.1 Organisational level

The first research area focuses on the challenges the hospitality and food service sector faces in preventing food waste. This research could explore the role that organisational structures, power relations, institutions, regulations and policies play and whether they facilitate or hinder waste prevention. Within this context, it would be valuable to test and measure how applicable and effective the proposed food waste prevention measures are to the sector in practice. This process could revise and refine the current recommendations offered in Chapter 4 to produce detailed industry guides for food waste prevention.

5.5.2 City or country level

The second area of research focuses on food surplus, the role it plays in food waste generation and its potential for food waste prevention. It is appropriate to investigate food surplus at a city or country level, because it is at this level where food surplus redistribution becomes logistically feasible. It is worth further exploring the notions of value in food surplus, how food surplus reduction could lead to food waste prevention, and what would be the trade-offs to be negotiated. Further research is also required to understand the conflicts in and limitations of food surplus redistribution in addressing food waste and structural food poverty.

5.5.3 Global level

The third research area examines food waste within the global food system. It is worth exploring where and if so how can food waste prevention contribute to achieving food security without compromising environmental and social welfare outcomes. This research could take a food system approach (Ingram et al., 2010) to consider the role that food waste prevention can play in strengthening resilience of the food system in the face of global environmental change.

5.6 Final reflections

One of the most profound impacts this PhD research process had on me is that I regard knowledge acquisition in a new way. This process spurred me to seek answers to the research questions that prompted me to study for a PhD in the first place. In the pursuit of these answers, I engaged with physical and social science disciplines,

formulated research questions and developed methodological approaches that combined elements of and crossed over these disciplines. This process helped me recognise the value of different epistemological perspectives in research design and inquiry. Such an approach brought an original and critical edge to addressing research questions of a complex nature. In addition, living and conducting my research in Malaysia helped me develop a deep appreciation of the importance of local cultures, systems and knowledge. As such, I now place considerable value in engaging with local actors to capture local knowledge and experiences that can contribute in many ways to our understanding of global problems and potential solutions particularly relevant to the field of sustainability research.

5.6.1 *The future of the global food system*

Ultimately, the final thought on this thesis is regarding the future of the global food system. As the number of undernourished people in the world fell below 800 million in 2015, a noteworthy achievement and significant progress was made towards the United Nations Zero Hunger target (FAO et al., 2015). Yet it is hard to remain optimistic when nearly one in ten people goes to bed hungry every night (World Bank Group, 2016). Food insecurity is one of the greatest challenges the world faces today and it is expected to become greater under the burden of increasing world population, geopolitical instability and global environmental change. A resilient and sustainable food system is therefore imperative (Ingram et al., 2010) and a combination of sound policies, regulations, knowledge and targeted investment is required to deliver a nutritious, safe and affordable diet for all in a sustainable way. Food waste research is only one small piece of this jigsaw puzzle and this thesis has hopefully made the final picture a little clearer.

5.7 References

- Alexander, C., Gregson, N. & Gille, Z. (2013). Food Waste, in: Handbook of Food Research, (pp. 471–483).
- Alexander, C. & Smaje, C. (2008). Surplus Retail Food Redistribution: An Analysis of a Third Sector Model. *Resources, Conservation and Recycling*, 52(11), 1290–1298.
- Blaikie, P. (1985). *The Political Economy of Soil Erosion in Developing Countries*. London; New York: Longman.
- Chen, H., Jiang, W., Yang, Y., Yang, Y. & Man, X. (2016). State of the Art on Food Waste Research: A Bibliometrics Study from 1997 to 2014. *Journal of Cleaner Production*. Retrieved from <http://www.sciencedirect.com/science/article/pii/S095965261501803X>

- European Commission. (2006). *Environmental Impact of Products (EIPRO)*. Spain.
- Evans, D. (2011a). Blaming the Consumer – Once Again: The Social and Material Contexts of Everyday Food Waste Practices in Some English Households. *Critical Public Health*, 21(4), 429–440.
- Evans, D. (2011b). Beyond the Throwaway Society: Ordinary Domestic Practice and a Sociological Approach to Household Food Waste. *Sociology*, 46(1), 41–56. Retrieved March 10, 2012, from <http://soc.sagepub.com/cgi/doi/10.1177/0038038511416150>
- Evans, D. (2014). *Food Waste. Home Consumption, Material Culture and Everyday Life*. London: Bloomsbury Academic.
- Evans, D., Campbell, H. & Murcott, A. (2013). *Waste Matters: New Perspectives on Food and Society* (D. Evans, H. Campbell, and A. Murcott, Eds.). Oxford: Wiley-Blackwell/ The Sociological Review.
- FAO, IFAD & WFP. (2015). *The State of Food Insecurity in the World: Meeting the 2015 International Hunger Targets: Taking Stock of Uneven Progress*. Retrieved from <http://www.fao.org/3/a4ef2d16-70a7-460a-a9ac-2a65a533269a/i4646e.pdf>
- Geels, F. W., Mcmeekin, A., Mylan, J. & Southerton, D. (2015). A Critical Appraisal of Sustainable Consumption and Production Research: The Reformist, Revolutionary and Reconfiguration Positions. *Global Environmental Change*, 34, 1–12.
- Goonan, S., Miroso, M. & Spence, H. (2014). Getting a Taste for Food Waste: A Mixed Methods Ethnographic Study into Hospital Food Waste before Patient Consumption Conducted at Three New Zealand Foodservice Facilities. *Journal of the Academy of Nutrition and Dietetics*, 114(1), 63–71. Retrieved from <http://dx.doi.org/10.1016/j.jand.2013.09.022>
- Gustavsson, J., Cederberg, C., Sonesson, U., Otterdijk, R. van & Meybeck, A. (2011). *Global Food Losses and Food Waste. Extent, Causes and Prevention*. Rome.
- Hawkins, G. (2006). *The Ethics of Waste: How We Relate to Rubbish*. Maryland: Rowman & Littlefield Publishers.
- Ingram, J. (2011). A Food Systems Approach to Researching Food Security and Its Interactions with Global Environmental Change. *Food Security*, 3(4), 417–431.
- Ingram, J., Erickson, P. & Leverman, D. (Eds.). (2010). *Food Security and Global Environmental Change*. Earthscan. Retrieved from

http://www.gecafs.org/publications/Publications/Food_Security_and_Global_Environmental_Change.pdf%5Cnhttp://medcontent.metapress.com/index/A65RM03P4874243N.pdf

- Kabongo, J. D. (2013). Waste Valorization, in: Idowu, S. O., Capaldi, N., Zu, L., and Das Gupta, A. (Eds.), *Encyclopaedia of Corporate Social Responsibility*, (pp. 2701–2706). Springer Berlin Heidelberg.
- Ki Lin, C. S., Koutinas, A. A., Stamatelidou, K., Mubofu, E. B., Matharu, A. S., Kopsahelis, N., et al. (2014). Current and Future Trends in Food Waste Valorization for the Production of Chemicals, Materials and Fuels: A Global Perspective. *Biofuels, Bioproducts and Biorefining*, (8), 686–715.
- Luque, R. & Clark, J. H. (2013). Valorisation of Food Residues: Waste to Wealth Using Green Chemical Technologies. *Sustainable Chemical Processes*, 1(10), 2–4.
- Maniates, M. F. (2001). Individualization: Plant a Tree, Buy a Bike, Save the World? *Global Environmental Politics*, 1(3), 31–52.
- Midgley, J. L. (2013). The Logics of Surplus Food Redistribution. *Journal of Environmental Planning and Management*, (March 2015), 1–21. Retrieved from <http://www.tandfonline.com/doi/abs/10.1080/09640568.2013.848192>
- Peet, R., Robbins, P. & Watts, M. J. (2011). *Global Political Ecology* (R. Peet, P. Robbins, and M. J. Watts, Eds.). London; New York: Routledge.
- Scott, A., Oates, C. & Young, W. (2015). A Conceptual Framework of the Adoption and Practice of Environmental Actions in Households. *Sustainability (Switzerland)*, 7(5), 5793–5818.
- Shove, E. (2010). Beyond the ABC: Climate Change Policy and Theories of Social Change. *Environment and Planning A*, 42(6), 1273–1285. Retrieved from <http://www.envplan.com/abstract.cgi?id=a42282>
- Southerton, D., McMeekin, A. & Evans, D. (2011). *International Review of Behaviour Change Initiatives*. Edinburgh.
- Sova, C. A., Helfgott, A., S. Chaudhury, A., Matthews, D., F. Thornton, T. & J. Vermeulen, S. (2014). Multi-Level Stakeholder Influence Mapping: Visualizing Power Relations Across Actor Levels in Nepal's Agricultural Climate Change Adaptation Regime. *Systemic Practice and Action Research*, 28(4), 383–409.
- Stuart, T. (2009). *Waste. Uncovering the Global Food Scandal*. London: Penguin.

- Tukker, A., Cohen, M. J., Hubacek, K. & Mont, O. (2010). The Impacts of Household Consumption and Options for Change. *Journal of Industrial Ecology*, 14(1), 13–30. Retrieved August 12, 2013, from <http://doi.wiley.com/10.1111/j.1530-9290.2009.00208.x>
- Urry, J. (2010). Sociology and Climate Change. *Sociological Review*, 57, 389–470.
- World Bank Group. (2016). Future of Food: Shaping the Global Food System to Deliver Improved Nutrition and Health. Retrieved from <http://documents.worldbank.org/curated/en/2016/04/26214706/future-food-shaping-global-food-system-deliver-improved-nutrition-health>
- Young, W., Davis, M., McNeill, I. M., Malhotra, B., Russell, S., Unsworth, K., et al. (2015). Changing Behaviour: Successful Environmental Programmes in the Workplace. *Business Strategy and the Environment*, 24(8), 689–703.
- Young, W., Hwang, K., McDonald, S. & Oates, C. J. (2010). Sustainable Consumption: Green Consumer Behavior When Purchasing Products. *Sustainable Development*, 18, 20–31. Retrieved from <http://eprints.qut.edu.au/29653/>

**Appendix A: Report on food waste minimisation policy options
for Malaysia**

Food waste minimisation policy options for Malaysia

by Universiti Teknologi Malaysia (UTM)

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7/2/2012

Executive Summary

This report outlines the strategy and policy options for food waste minimisation in Malaysia. It is the product of a series of stakeholder engagement and knowledge exchange activities between Malaysian food waste stakeholders and UK food waste experts. Successful examples of food waste prevention and minimisation in the UK were also studied in order to identify potential policy options for Malaysia. The UK was selected as a case study because of the country's achievements in food waste prevention and minimisation; one example being the 13 per cent reduction of food waste generated in the household in the period between 2006/07 and 2009/10.

Food waste prevention can deliver the highest environmental, economic and social benefits in the long-term, therefore it should be a strategic priority for Malaysia. After food waste prevention, policy options for the management of the unavoidable food waste fraction have been identified as the re-use of food surplus, composting and recycling food waste as animal feed, and finally generating energy via Anaerobic Digestion.

It is recommended that a solid and comprehensive evidence base is developed to guide the policy formulation process and to prioritise and support its implementation. This includes data on food waste generation rates, composition, sources, as well as reasons behind food waste generation, current practices, barriers and drivers for waste prevention and minimisation.

Policy implementation mechanisms and tools rewarding food waste minimisation and penalising wasteful practice, in the form of landfill and other types of environmental tax and regulation, can act as a driving force to more sustainable practices. These tools need to be supported by tight enforcement and complemented by industry voluntary agreements, 'industrial symbiosis' networks, food surplus redistribution schemes, industry specific guidance and standards for food waste minimisation by the food manufacturing and processing, retail, food service and hospitality sectors. Guidance and communication campaigns on how consumers can prevent food waste at the household level, compost and/ or segregate food waste when it does arise, are also essential.

Finally, due to the iterative nature of the policy formulation and implementation process, longstanding commitment and continuous effort is required to deliver long-term change towards a more sustainable solution to the food waste challenge in Malaysia.

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Acronyms

AD: Anaerobic Digestion

Defra: Department for Environment, Food and Rural Affairs

FCO: Foreign and Commonwealth Office

GHG: Green House Gases

MHLG: Ministry of Housing and Local Government

MSW: Municipal Solid Waste

NGOs: Non-Governmental Organizations

SRA: Sustainable Restaurant Association

UTM: Universiti Teknologi Malaysia

WRAP: Waste and Resource Action Programme

Introduction

Project Background

This report is the product of the 'Food Waste Management Policy in Green Townships in Malaysia' project, hereafter referred to as the 'Project'. The Project commenced in August 2011, when the Foreign and Commonwealth Office (FCO) awarded the South East Asia Prosperity Fund to the Universiti Teknologi Malaysia (UTM). UTM acted as the implementing organisation of the Project with the support of the British High Commission in Kuala Lumpur. The Project team structure is illustrated in Figure 1 below. The Project falls within the SE Asia Prosperity Fund's remit of promoting a low carbon, high growth, global economy and supporting climate change policymaking throughout SE Asia.

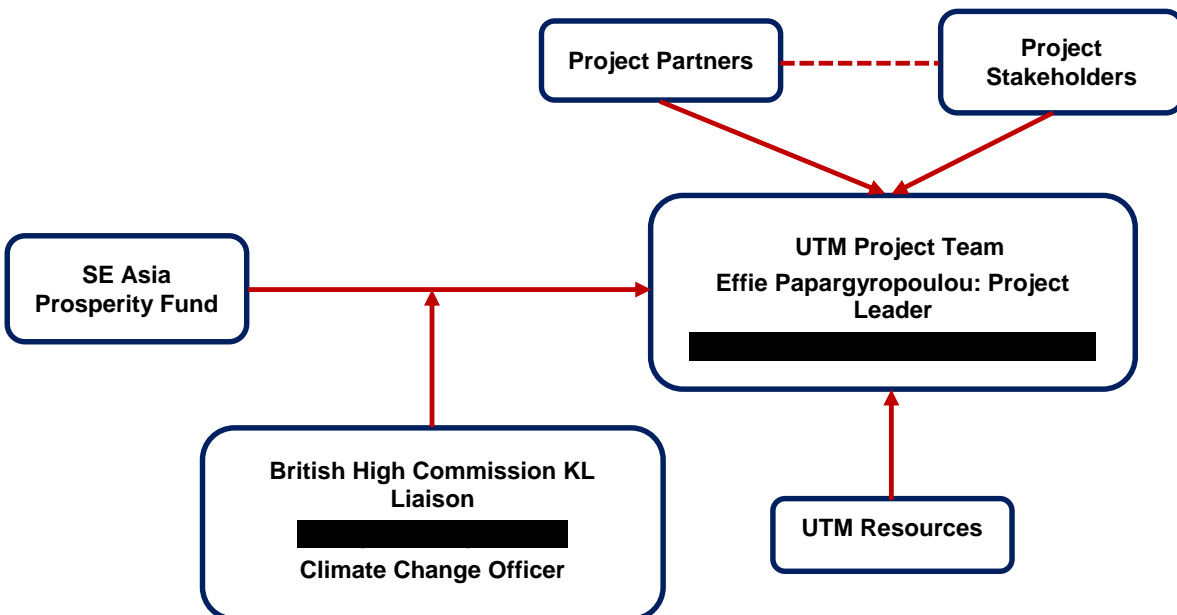


Figure 1: Project Team Structure

The Project team worked closely with the National Solid Waste Management Department, hereafter referred to as the 'Department', to facilitate the Department's policy development process focusing on food waste minimisation. During the one-year project duration, three stakeholder engagement activities were organised, followed by interviews with the project partners, Malaysian stakeholders and international food waste experts (Figure 2). This report represents the final output of the Project and outlines policy options for food waste minimisation in Malaysia. The Project's aim, scope and methodology are discussed in more detail below.



Figure 2: Project Partners

Project Aim

The aim of the Project is to identify the critical elements required for a food waste minimisation policy in Malaysia. This report is aimed at Malaysian policy makers in relation to food waste and in particular the National Solid Waste Management Department of the Ministry of Housing and Local Government.

Project Scope

This project focuses on food waste minimisation in Malaysia and approaches the problem at a policy level. For the purposes of this project, food waste minimisation includes prevention, re-use and recycling in the form of animal feed production from food waste. In order to provide a holistic approach to the food waste challenge, options of recycling through composting and energy from waste i.e. Anaerobic Digestion (AD) are discussed in this report. However, emphasis is placed on food waste prevention for two principle reasons: firstly, it is considered the most advantageous option from an economic, social and environmental perspective (refer to Section 3.1) and; secondly, to date, there has been less consideration of this important food waste minimisation strategy in Malaysia.

Although it is recognised that food waste is derived at every stage of the food production and consumption cycle through a number of sources (i.e. agriculture, food processing and manufacturing industry, retail sector, food service and hospitality sector, and households), food waste from agriculture falls outside the scope of the project.

Waste Management in Malaysia

In Malaysia, waste minimisation, recycling and management efforts are the responsibility of the Ministry of Housing and Local Government (MHLG). The 2007 Solid Waste and Public Cleansing Management Act involved major restructuring of the waste management sector by transferring the responsibility and authority of waste collection from the Local Authorities to the Federal Government (Government of Malaysia, 2007). In addition, it adopted 22 year concessions for three private waste collection companies, allowing for long-term visibility with the aim to encourage strong private investment. Two newly formed federal institutions, the National Solid Waste Management Department and the Solid Waste and Public Cleansing Management Corporation (hereafter referred to as the 'Corporation') are responsible for the implementation and enforcement of the Act, with the latter being the operational arm. Waste management legislation adopted in the last five years forms the basis of policy to support the government's target of 20 per cent recycling, 100 per cent separation at source and closure of all historic, unsanitary dumping sites by 2020 (Ministry of Housing and Local Government, 2005). Whilst these targets are undoubtedly aspirational, they are an on-going challenge for the existing waste management regime.

Currently, recycling is estimated to be approximately 5 per cent (National Solid Waste Management Department, 2010). Although anecdotal evidence suggests this figure is growing, it is still falling considerably short of the government's target of 20 per cent. In terms of disposal of waste, landfill dominates with 95 per cent of waste collected being disposed in one of the 112 landfills (United Nations Development Programme, 2008). According to the MHLG, the majority of landfills are at full capacity and operate to old standards with minimal leachate and landfill gas control. The lack of disposal alternatives is partially manifested by the fact that collection costs make up 83 per cent of the total waste management budget (National Solid Waste Management Department, 2010). Considering the high proportion allocated to waste collection, limited resources remain to address upstream sustainable waste management activities such as minimisation, reuse, recycling, waste treatment and the production of energy from waste.

The challenges surrounding waste faced by Malaysia can be better understood when considering the local conditions and the impact on waste management. Compared with developed countries, the Municipal Solid Waste (MSW) in Malaysia has a lower content of paper, glass, plastic and metal and a higher percentage of food waste (United Nations Development Programme, 2008). Food waste, in particular, has a relatively

high water content and, in the case of Malaysia, a relatively high oil and grease content. This results in a dense waste which is more difficult to handle. The particular nature and composition of Malaysia's waste has implications on the selection of containers, collection vehicles, waste management and treatment systems.

The frequency of waste collection is another noteworthy feature of Malaysian waste management. The country's high humidity and temperatures accelerates the decomposition of organic waste, making daily collections a necessity due to health and safety, as well as social amenity concerns such as issues of smell. Daily waste collection has implications, not only in terms of the increased work force required but also in terms of the equipment and its maintenance. Difficulties in reaching inaccessible sites or premises, especially in villages and unplanned settlements, add further complications to the waste collection task.

A further factor to consider is the revenue generating mechanism to finance waste management activities. Currently, the existing mechanism is not sufficient to cover the associated costs, leaving the waste collection authorities in need of subsidies from the federal government. Encouragingly, the new Solid Waste and Public Cleansing Management Act promises to support investment by the private sector by adopting 22 year concessions for the waste collection companies, giving them long-term visibility, as mentioned previously.

Considering the present state of waste management in Malaysia, the Department has the demanding task of bridging the gap between policy and practice. The newly formed Department is faced with the challenge of addressing a number of factors that historically have contributed towards the disconnection between policy and practice, including limited policy implementation, weak regulatory enforcement, limited stakeholder coordination and low public awareness of the environment and, more specifically, waste prevention and sustainable management. These are some of the areas where this project aims to support the Department's efforts towards sustainable waste management, in particular in relation to food waste.

Food Waste in Malaysia

Food waste, compared to other waste types, is a unique issue in Malaysia for a number of reasons. By examining the composition of the MSW in Malaysia in Figure 3, it is clear that food waste represents the single largest waste stream accounting for 45 per cent of the total MSW, and thus offers great potential for waste minimisation, recycling and energy recovery.

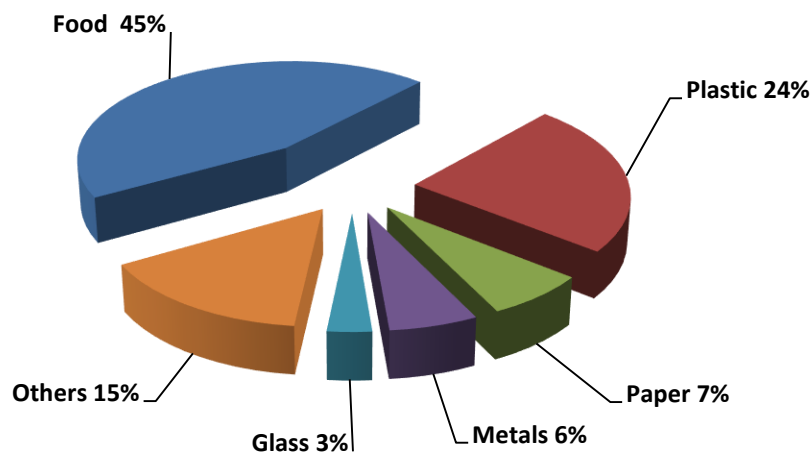


Figure 3: Malaysia’s Municipal Solid Waste Composition

(Source: National Solid Waste Management Department, www.kpkt.gov.my)

In addition, the proliferation of cafes and food stalls reflects the relatively low cost of food, meaning the majority of the population can afford to eat out rather than prepare food in the home. When addressing the issue of food waste in Malaysia, it is therefore important to recognise that the foodservice and hospitality sector is rapidly growing and competing with the household as one of the biggest sources of food waste. Other sources of food waste in Malaysia include the retail sector, the food processing and manufacturing industry.

Food Waste Stakeholders in Malaysia

The principal food waste stakeholders in Malaysia, as identified in this project are presented in Figure 4 below.

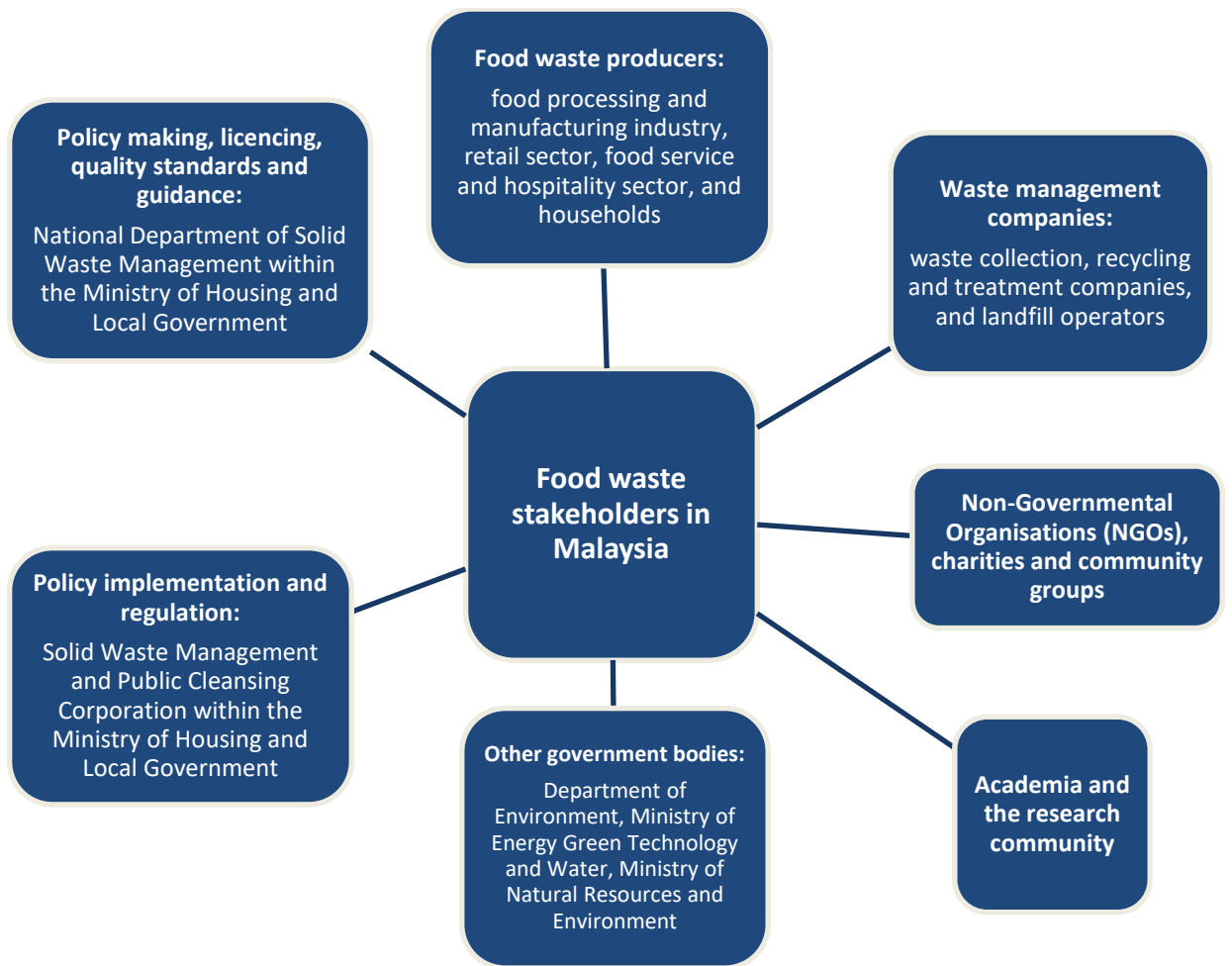


Figure 4: Food Waste Stakeholders in Malaysia

Project Methodology

Problem Definition

As highlighted in the previous section, Malaysia's food waste makes up nearly half of the total MSW stream. Therefore, tackling food waste through minimisation could contribute significantly towards the country's target of 20 per cent recycling rate by 2020. From an environmental view point, food waste minimisation has significant advantages in terms of resource efficiency (Defra, 2007) and greenhouse gas emissions (GHG) reduction. It is increasingly recognised that the production and consumption of food, makes a significant contribution to total GHG (EC, 2006; WWF-UK, 2006; UNEP, 2008). In Asia in particular, it is reported that the Food & Drink sector makes up approximately 20 per cent of global GHG emissions (EC, 2008). Food waste is an important contributor to the sector's overall GHG emissions.

There are two principle GHG impacts arising from food waste generation. Firstly, food waste generates GHGs when disposed in landfill. Degradation of all biodegradable wastes in landfill produces potent GHGs, such as carbon dioxide and methane. Secondly, and far more significant from a climate change perspective, is the embedded GHG emissions associated with food waste. Food waste embodies all previous life cycle stage impacts from food production and consumption (e.g. agriculture, transportation, food manufacturing, refrigeration and retail).

An additional benefit of waste minimisation systems is that they can deliver cost savings further down the line, in relation to collection, transportation, treatment and disposal of waste. By preventing waste, less effort and cost is required in terms of collection and treatment. In Malaysia, where the single biggest waste management cost is associated with collection, waste prevention can deliver substantial cost savings.

The primary driver behind food waste minimisation efforts in Malaysia is not alleviation of poverty, which might be the case in some of its neighbouring countries. Addressing waste management is one of the prerequisites for Malaysia to achieve 'developed nation' status in the next decade and demonstrate the country's commitment to sustainability.

Project Approach

As stated above, the aim of this project is to identify the critical elements required for a food waste minimisation policy in Malaysia. This project attempts to achieve this by identifying priority areas for consideration and proposing means of overcoming the current barriers to a more sustainable food waste management strategy. The approach

taken and the methods involved are presented in the table below. The stakeholder engagement exercises carried out as part of this project and their outputs are discussed in Section 3.2.1.

Table 1: Project Methodology

Project Stage	Method
Understand and define the problem	<p>Review existing national policies and strategies on waste management, climate change, sustainable development, economic growth, renewable energy, and environmental protection</p> <p>Stakeholder engagement activities, semi-structured interviews with Malaysian stakeholders</p>
Identify key stakeholders, their interests and roles	Stakeholder engagement activities and semi-structured interviews with Malaysian stakeholders
Identify barriers and opportunities to food waste prevention and more sustainable food waste management options	Stakeholder engagement activities and semi-structured interviews with Malaysian stakeholders
Facilitate the development of a ‘vision position’ for food waste prevention and minimisation in Malaysia	<p>Use international case studies of successful waste minimisation projects and initiatives as examples of best practice:</p> <p>introduce UK food waste experts to the Malaysian stakeholders through knowledge exchange activities</p> <p>organise UK trip for the Malaysian policy-makers’ delegation to experience first-hand successful food waste prevention and minimisation initiatives and projects</p>
Develop policy options recommendations framework on how to link current position to proposed ‘vision position’	<p>Identify the critical elements of a food waste prevention and minimisation policy and strategy relevant to Malaysia</p> <p>Combination of all of the above methods</p>

The UK Case Study

The UK was selected as one of the most useful case studies to be examined and used as an example of best practice for Malaysia. The latest estimates on food waste suggest that the UK food waste household generation was reduced by approximately 13 per cent in the period between 2006/07 and 2009/10 (WRAP, 2011). This figure represents solely food waste prevention at source, not even including food waste recycling and energy recovery efforts that further reduced the amount of food waste going to landfill. Although a number of different factors are likely to have contributed to the observed decrease of food waste generation at the household, this figure is nonetheless a commendable result towards food waste prevention. In addition, according to Defra's latest waste policy review, England managed to increase the average household waste recycling rate from 10 per cent in the year 2000/01, to 40 per cent in year 2010/11 (Defra, 2011). The UK's achievements in recycling and food waste prevention make it one of the most successful case studies for food waste prevention and minimisation.

Stakeholder Engagement Activities

Stakeholder Engagement Workshop – October 2011

The first stakeholder engagement activity of the project was a half-day workshop on 'Sustainable Food Waste Management Policy in Malaysia'. The workshop was held on 25 October 2011 in Kuala Lumpur.

The aim of the activity was to bring together stakeholders central to the development of a sustainable food waste management policy in Malaysia, introduce the project, communicate the progress made by the MHLG, as well as the ministry's existing projects on food waste management, and initiate dialogue between the parties involved.

The speakers at the workshop were:

- [REDACTED], [REDACTED] the British High Commission Kuala Lumpur,
- Ms. Effie Papargyropoulou Project Leader 'Sustainable Food Waste Management in Green Townships' project and UTM Visiting Lecturer,
- [REDACTED] Perdana School of Policy at UTM, and
- [REDACTED] – Ministry of Environment Japan collaboration project on the development of a strategic plan for food waste management in Malaysia'.

The workshop attracted participants from private waste collection and management companies such as Alam Flora Sdn. Bhd. and SWM Environment Sdn. Bhd., representatives from the Ministry of Housing and Local Government, the National Solid Waste Management Department, the Solid Waste Management and Public Cleansing Corporation and academics from UTM and Universiti Kebangsaan Malaysia.

Knowledge Exchange Workshop – January 2012

The second project activity was a full day workshop, entitled 'Food Waste Minimisation: A UK Perspective' held on 31 January 2012, in Kuala Lumpur.

The aim of the workshop was to bring together the Malaysian food waste management stakeholders, facilitate knowledge exchange between the UK and Malaysia, and stimulate dialogue between the parties involved. The discussions aimed to identify the critical elements of food waste minimisation policies and strategies relevant to Malaysia. The findings that emerged from these discussions were later incorporated into this policy options report.

In order to stimulate a constructive, critical and balanced debate amongst the stakeholders, four UK food waste specialists were invited as speakers. The food waste specialists presented their experiences and perspectives, and suggested potential parallels between the two countries. The speakers were purposely selected from different backgrounds and represented different segments of the UK food waste management arena. [REDACTED]

[REDACTED]

Aside from the representatives from the MHLG, the Solid Waste Management Department, the Solid Waste Management and Public Cleansing Corporation, the workshop also attracted some non-governmental organizations (NGOs), academics from several universities as well as representatives from the hospitality and food services sector. [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

UK Visit by the Malaysian Delegation – April 2012

The final project activity took place in April 2012 and involved a visit to the UK by a Malaysian delegation. The Malaysian delegation comprised of [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED].

The aim of the visit was to showcase best practice examples of food waste prevention and minimisation in the UK and expose the Malaysian delegation to the viability of sustainable food waste management practices. The visit consisted of meetings with UK food waste experts and site visits to successful food waste minimisation projects. The organisations and projects visited represented different aspects and segments of the UK food waste management sector. They included governmental organisations such as the Department for Environment, Food and Rural Affairs (Defra) and the Waste and Resource Action Programme (WRAP), charities such as FareShare, private research and engineering consultancies such as Brook Lyndhurst and SKM Enviros, business associations such as the Sustainable Restaurant Association and, finally, academia with Harper Adams University College. The participants from the different organisations are presented in Table 2 below.

Table 2: UK Visit Meetings Participants

Organisation	Participants
Defra	[REDACTED] [REDACTED] [REDACTED]
WRAP	[REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED]
FareShare	[REDACTED] [REDACTED] [REDACTED] [REDACTED]

Organisation	Participants
Brook Lyndhurst	[Redacted]
Sustainable Restaurant Association (SRA)	[Redacted]
Harper Adams University College	[Redacted]
SKM Environs	[Redacted]

The meetings and visits offered a platform for discussion and debate on:

- The current UK food waste, AD and composting policy, its development process, its implementation mechanisms and the regulatory framework to support it;
- research and the process of building the evidence base to guide and support policy;
- UK government programmes on food waste prevention and sustainable management at the household level and how the government is engaging with the private sector (manufacturing, retail, food service and hospitality, and waste management sectors) to promote more sustainable practices;
- The technical, financial and operational challenges behind AD of food waste;
- Roles, responsibilities and interface between all the stakeholders including the government, the local authorities, the public, the private sector, the waste management sector, the third sector and the research community; and
- Initiatives and voluntary agreements for the retail, food service and hospitality sector on reducing food waste and moving towards more sustainable waste management practices

The discussions covered a number of food waste sources such as the household, food processing and retail sector, the food service and hospitality sector, as well as institutions such as schools, rehabilitation centres, hospitals and others. A wide range of options to address surplus food and food waste were debated ranging from prevention, minimisation, reuse, recycling, composting and AD, as well as the associated issues of waste collection, regulatory, financial, operational, and non-technical aspects such as public awareness, participation, education, behaviour

change and others. This provided a rounded view of the elements required for an integrated and successful policy to address food waste in a sustainable manner.

Limitations

The policy options presented in this report emerged from a number of stakeholder engagement and knowledge exchange activities, drawing expertise from international successful examples of food waste minimisation. Therefore, this project's methodology is purely of a qualitative nature. Quantitative data on food waste generation rates and sources would have further informed the outcomes of this project were not available at the time of writing. In addition, the timescale for this project was limited for funding-related reasons and the project drew knowledge and experience primarily from UK. It is therefore recognised, that a larger scale project, examining the approaches that other countries have taken would be beneficial in the policy formulation process for Malaysia. The project team acknowledges these limitations and recommends additional studies to complement and build on the findings of this project.

Critical Elements to a Food Waste Minimisation Policy

In this section, the critical elements to a food waste minimisation policy are discussed, as derived from the project's activities.

Food Waste Hierarchy

Malaysia's broader solid waste management policy framework is based on the 3Rs concept of Reduce, Re-use, Recycle. In line with this concept, this project suggests a more comprehensive approach, providing more detail on the options available for food waste prevention, minimisation and sustainable waste management. Drawing inspiration from the 'Waste Hierarchy' described in the European Waste Directive (EC, 2008), the Food Waste Hierarchy is proposed, as illustrated in Figure 5.

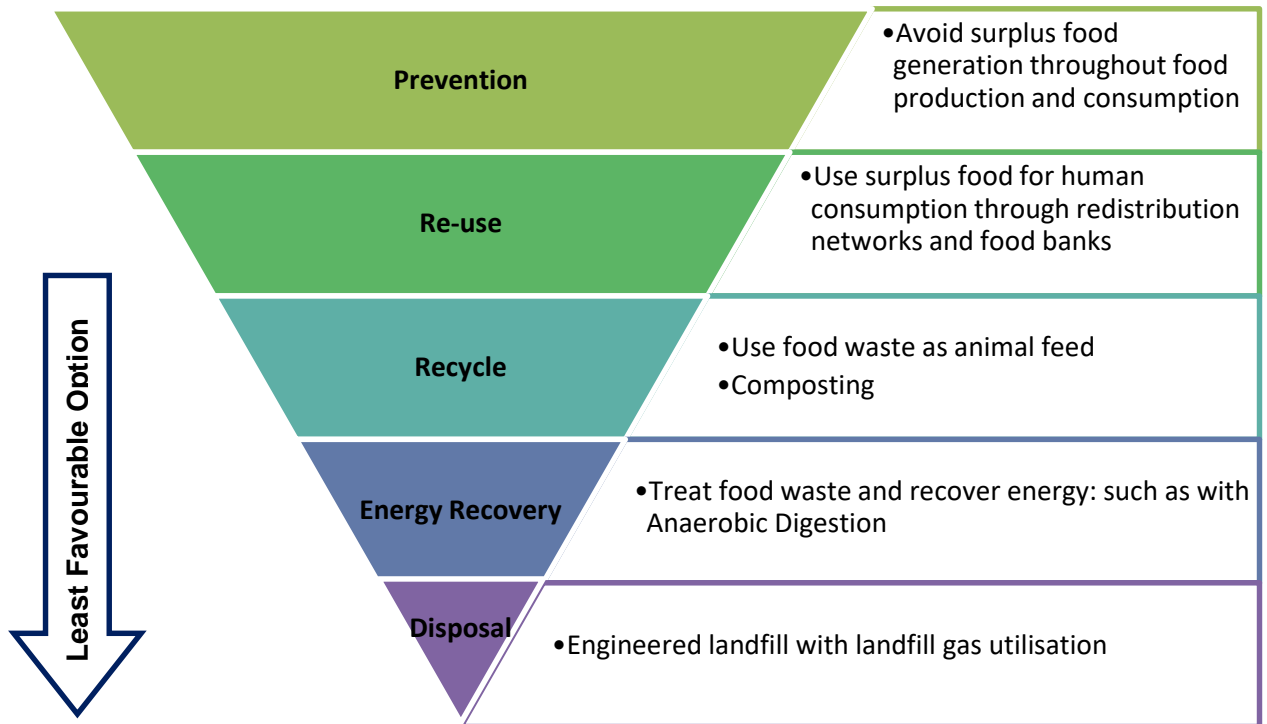


Figure 5: Food Waste Hierarchy

In the Food Waste Hierarchy, prevention is the preferred option. This can be achieved by avoiding the generation of food surplus throughout the food production and consumption cycle.

Once all the efforts for prevention have been exhausted, re-use of edible surplus food for human consumption is the next best option. This requires an organised and sophisticated collection and redistribution system in place, ensuring food safety and safeguarding against commercial conflict of interests.

Food surplus that is not fit for human consumption can then be recycled either by becoming animal feed or by being composted to produce soil conditioner.

Unavoidable food waste can be treated with AD technologies to generate energy in the form of biogas and soil conditioner in the form of digestate.

The last option for the remaining fraction of unavoidable food waste is disposal. Disposal should however be in the form of fully engineered, sanitary landfills with landfill gas utilisation systems in place.

Policy Elements


Through engagement with the stakeholders illustrated in Figure , the following elements critical to the development of a food waste minimisation policy for Malaysia were identified and are discussed below.

Food Surplus vs. Food Waste

In policy for food waste minimisation, an important distinction needs to be made between the terms ‘food surplus’ and ‘food waste’. Often food surplus is incorrectly referred to as food waste, missing the subtle difference between the two terms.

In this report, food surplus is defined as food produced beyond our nutritional needs, whereas waste is a product of food surplus. Agronomists advise that up to a point, food surplus acts as a safeguard against unpredictable weather patterns effecting crops, for example that can affect the food supply chain. They suggest that a food supply of 130 per cent over our nutritional needs should guarantee food security (Smil, 2004; Bender, 1994). However, as documented by researchers such as Tristram Stuart (Stuart, 2009) and the Food Agriculture Organisation of the United Nation, the scale of global food surplus is in fact threatening not safeguarding global food security (FAO, 2010).

The distinction between the two terms is crucial when assessing the options available to address the food waste challenge. Food surplus should be avoided throughout the production and consumption cycle and where it is not, food surplus should be re-used for human consumption. As soon as food surplus becomes unfit for human consumption, it is then considered food waste.

	<p><u>The Role of the Third Sector</u></p> <p>Foodcycle and FareShare are two charities in the UK that contribute to food waste minimisation by redistributing food surplus to communities in need. They source food surplus from the retail sector, the interface between the food manufacturing industry and retail, as well as the food service sector. Volunteers are central in the operations of both charities, and their work helps not only to reduce the amount of food waste produced in the UK, but also to fight food poverty.</p>
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Avoidable vs. Unavoidable Food Waste

Another important distinction that needs to be made is the one between ‘avoidable’ and ‘unavoidable’ food waste. This report proposes the following definitions, adapted from WRAP (WRAP, 2009).

Avoidable food waste – food thrown away because it is no longer wanted or has been allowed to go past its best. The vast majority of avoidable food is composed of material that was, at some point prior to disposal, edible even though a proportion is not edible at the time of disposal due to deterioration (e.g. has since become mouldy). The

category of 'avoidable' includes foods or parts of food that are considered edible by the vast majority of people.

Unavoidable food waste – waste arising from food preparation that is not, and has not been, edible under normal circumstances by the majority of people. This includes parts of foods such as pineapple skin, apple cores and meat bones.

What is considered edible by 'a majority of people' depends on a number of factors, such as culture in the form of shared values and common practices, religious beliefs, social norms and personal preference. Despite its potentially subjective nature, the distinction between avoidable and unavoidable food waste is a pivotal one in the formulation of policy of food waste minimisation, because it provides insight into the degree to which food waste prevention is feasible. There will always be an amount of food waste produced that is unavoidable and that is why it is crucial to exhaust the options of prevention, re-use and recycling for the avoidable fraction, before reserving the option of energy recovery for the unavoidable fraction.

Waste Prevention vs. Waste Management

One of the fundamental principles of the proposed Food Waste Hierarchy (Figure 5) lies in the distinction between 'waste prevention' and 'waste management'.

There are occasions when the waste hierarchy is wrongly referred to as the waste management hierarchy. This misconception originates from the fact that the hierarchy was initially developed as a tool designed to assist in identifying the most appropriate solution, once waste was generated. As the focus shifted away from a mere pollution prevention control exercise, and the concepts of sustainable resource management, life cycle management and Sustainable Consumption and Production began altering the way 'waste' was perceived, a clear divide between waste prevention and waste management options was established. Waste prevention includes activities that avoid waste generation for instance reduction of food surplus, whereas waste management includes the options available to deal with food waste, once it has been generated, such as AD.

This report also refers to waste minimisation, which for the purpose of this project includes prevention, re-use and recycling of food waste by converting it into animal feed.

Solid Evidence Base

One of the main points that came out from the knowledge exchange activities with the UK was the central role a solid evidence base plays in guiding the direction, but also

supporting the implementation of food waste policy. Up-to-date, reliable and detailed information about the sources, quantity and composition of food waste will highlight priority areas and will be necessary for the continuous development of targeted strategies.

Information regarding aspects of food waste other than its physical properties is also essential. This includes information revealing the reasons behind food waste generation, the current waste management practices, the motivations for waste prevention, re-use, recycling and energy recovery, the practical, behavioural and social factors that influence the way food waste is generated and handled. By understanding these aspects of food waste, future strategies can be more effective in meeting their objectives.

A solid evidence base is also required to develop a comprehensive baseline. This will enable monitoring to measure progress and evaluate the level of success interventions and strategies have.

Reliable and comprehensive evidence on the scale of the problem and its implications to the environment, economy, society, industry and the individual can be a very powerful tool. It can help convince the industry and the general public to support and participate in the proposed strategies to tackle food waste. In the case of the UK, WRAP's clear message backed up by evidence, on the potential cost savings of food waste prevention, is increasing support and participation from the consumer and the industry.

It is important to view the development of the evidence base as a continuous, reiterative process, not a one-off exercise. This process also needs to be flexible and responsive to new findings, evolving as the food waste landscape changes.

Finally, in the case of Malaysia, some data on waste generation is available and studies from a number of sources have been conducted in the past. It is essential for the existing knowledge to be consolidated and coordinated as new studies and projects emerge. The role of managing information and evidence on waste can be performed by a central unit, which is also responsible for communicating it to the public and making it openly available.

WRAP

WRAP (Waste & Resources Action Programme) is a not-for-profit organisation, supported by governmental funding from England, Scotland, Wales and Northern Ireland. It assists businesses and individuals reduce waste, develop sustainable products and use resources in an efficient way. WRAP estimates that 8.3 million tonnes of food is wasted every year in the UK (WRAP, 2009), one third of all food that is bought. Most of this is avoidable and could have been eaten, with less than a fifth being truly unavoidable (such as bones, cores and peelings).

Why is food wasted?

In 2007, WRAP launched its 'Love Food, Hate Waste' campaign, aiming to address the reasons behind food waste at the household level. Based on WRAP's research undertaken in the UK (WRAP, 2007), avoidable food waste in households is produced due to:

- buying too much – particularly being tempted by special offers, e.g. 'buy one, get one free'
- poor storage management – not eating food in date order (choosing food on impulse, often driven by 'spontaneous' shopping)
- preparing/cooking too much food,
- high sensitivity to food hygiene – 1 in 5 say they would not take a chance with food close to its 'best before' date, even if it looked fine
- buying more perishable food – often as the result of trying to eat more healthily
- not liking the food prepared – 22 per cent of families with children stated that not liking a meal was a cause of food waste
- lifestyle factors – not having the time to plan meals, or having fluid work and social patterns, particularly true of young professionals

Intervention Strategy at the Household Level

The 'Love Food Hate Waste' campaign is targeting the reasons behind food waste at the household level by emphasising the true financial and environmental cost associated with food waste and by providing advice to the public on how to avoid it. One of the ways to communicate with the public is through the internet, and a dedicated 'Love Food Hate Waste' website. The campaign gives advice on:

- better planning during food shopping to avoid buying too much food or food that is not needed,
- accurate food portions to avoid cooking and serving too much food,
- efficient storage of perishable food and better understanding of 'sell by' and 'consume by' dates, to avoid fresh food getting spoiled or going off, and
- recipes by celebrity chefs for cooking leftover food.

Food Waste Prevention Evidence

The latest estimates on food waste suggest that the UK food waste household generation was reduced by approximately 13 per cent in the period between 2006/07 and 2009/10.



Coordination and Integration

Coordination and integration between different policies and strategies on a national level is a prerequisite for any policy to be effective. Because policies are often produced by the individual relevant government bodies, there is a risk for them to be developed in isolation. This can create conflict and result to the policies being less effective. For example, Malaysia's strategies on sustainable development, economic growth, agriculture and renewable energy are very relevant to waste management, therefore coordination between the individual policy teams is required.

One example related to food waste that demonstrates how the lack of coordination and integration between policies can compromise their aims, is that between the current waste management policy promoting the 3Rs concept and the one subsidising food supply. Subsidies mask the true cost of natural resources, keeping the price of food relatively low. The low cost of food is then inevitably linked to unsustainable production and consumption patterns, known to result to waste generation. By masking the true cost of food, the cost saving incentive for food waste prevention is weakened significantly, compromising the efforts of the 3Rs campaign. This is why solid waste management strategies need to be considered within the broader scope of resource efficiency, addressing the whole life cycle of materials and natural resources.

Implementation

Another critical element to a successful food waste prevention policy for Malaysia is a suitable implementation plan. The policy and strategies might have the right approach; however, they risk failure if they are not complimented by strong implementation plans. Identifying the appropriate options for the local context is only one element critical to a successful policy, the other being to identify the most appropriate methods to ensure its smooth implementation.

A mixture of regulation, financial incentives and disincentives, guidance and technical standards, and voluntary agreements can support the policy implementation process. Currently, the regulatory framework relevant to solid waste management relates to some aspects of environmental protection and permitting of disposal facilities. If Malaysia is to move away from heavy landfill reliance towards waste prevention, the regulatory context needs to be extended and tightened. One example is the current interest in the technology of AD for the treatment of organic waste. Before proposals for AD facilities can be contemplated, careful planning and consideration needs to be given to the regulatory framework required for such technology. This involves regulation to guide the planning process of such facilities, control operation and monitor emissions. It also includes technical standards and industry guidance, quality

standards regarding the products of AD facilities such as the digestate to cover both health and safety and religious considerations. Other issues that would need to be considered and decided upon centrally are related to the energy output of the AD plants, the uses of the digestate, as well as aspects related to the development of a market for the digestate, the sourcing of quality feedstock and the duty of care obligations throughout all the stages of the process.

The regulatory framework should also be complemented by strong enforcement. Currently, enforcement has been identified as a weakness and efforts are made by the Corporation, the Department and the DoE to address this. This weakness is partially due to lack of resources, suitably qualified enforcement officers and coordination amongst the different law enforcement bodies, as well as low fines for offenders that are not acting as a strong deterrent for bad practice. A tight, comprehensive, systematic, coordinated enforcement plan supported by sufficiently harsh penalisation is another of the critical elements to the policy for food waste prevention this report suggests.

Finally, the implementation strategy should not solely rely on deterrents for bad practice but provide incentives for good practice at the same time. Financial incentives such as capital grants, tax rebates and low interest loans can prove useful tools to stir the market towards the desired direction and remove some of the risks associated with pioneering practices and scepticism about new technologies and approaches.

Waste Policy in England

In the recent review of the waste policy in England by Defra, food waste is seen as a priority waste stream due to its high carbon impact. Prevention is seen as a priority too, supported by re-use and recycling to deal with waste, when waste does arise. The Government pledges to work with and support businesses, local authorities and third sector organisations to help reduce avoidable food waste in the home, the supply chains, across the public sector and within businesses themselves.

It is recognised that government intervention is required in order to produce the optimal situation, when the market alone is not doing so. Landfill and other types of environmental tax are identified as suitable instruments to deliver the desired outcomes in a cost effective way. However, it is highlighted that these need to be complimented by other mechanisms such as voluntary agreements and regulations. In England, these interventions have resulted in an increase of the average household waste recycling rate from 10 per cent in the year 2000/01, to 40 per cent in the year 2010/11.



Government Review
of Waste Policy in
England 2011



Effective Stakeholder Engagement

Input and buy-in from the stakeholders are crucial in ensuring a successful policy formulation and implementation. The food waste stakeholders in Malaysia, as illustrated in Figure 4, include representatives from the industry, the waste management sector, the public, the research community, as well as relevant government bodies. One method of engaging with the industry is through voluntary agreements. By initiating voluntary agreements tailored around the needs of individual industries, the Department can gain valuable insight and knowledge on the drivers and levers required for industry participation and support. This can also act as a first step, preparing the industry for future mandatory measures.

The participation of and support by the public is central in all this. Therefore, public consultation prior to introducing new policies, measures and projects is required as the public is one of the most important stakeholders. The timing of the consultation is critical in order for it to be meaningful and effective. Recent examples of public opposition during and following construction of incinerators in Malaysia (Pulau Tioman, Cameron Highlands and Pulau Langkawi) demonstrate how crucial it is for the public to be consulted during the decision making process, rather than be presented with an ultimatum at the implementation stages. Public engagement should also continue following the implementation of any proposals and be considered as a long-term process and not as a one-off task performed purely to satisfy a requirement. This is particularly pertinent in relation to the planning of waste management facilities and the success of new campaigns, which rely on public participation. Public engagement can take the form of awareness raising initiatives, educating the public on their role in government policy and empowering them by highlighting the contribution they can make.

Long-term Commitment

Finally, one of the points often neglected in waste management forums and debates is that change in environmental practice and behaviour takes time. For instance, one of the factors often quoted as a reason why initiatives have been unsuccessful in Malaysia is that of public resistance to any change in current practices, one example being limited participation in recycling schemes. Putting aside the other reasons that contribute to low recycling participation rates; it is important to acknowledge that Malaysia has only recently introduced such schemes and therefore the majority of the public are still getting to grips with what is being asked of them. Similarly, the industry is hesitant and cautious towards new schemes, challenging their tried and tested traditional practices.

As the UK case illustrates in the year 2000/01, only 10 per cent of household waste was recycled in England. It took a decade of continuous efforts to increase this figure to 40 per cent in the year 2010/11. As the 2011 'Government Review of Waste Policy in England' by Defra (2011) highlights, there is not a single and simple solution to solving waste and the progress made towards more sustainable waste management was the result of a continuous cycle of adjusting, refining and improving of strategies and approaches. Therefore, in the Malaysian context, long-term commitment to food waste minimisation is required beyond the time constraints of individual campaigns and competing political landscapes in order to deliver long-term change (Figure 6).



Figure 6: The Reiterative Policy Formulation Cycle

Policy Options Framework

Considering the unique characteristics of the local context, the experiences and knowledge shared by the successful examples of food waste minimisation in the UK, and the invaluable insight and input from the Malaysian food waste stakeholders, the following section puts forward a number of policy options for consideration by the Department in their national policy formulation process. The proposed policy options are organised in a framework for food waste minimisation based on the Food Waste Hierarchy discussed in Section 4.1, bringing together the critical elements identified in the previous section.

It is recognised that different options and approaches will be appropriate for the different food waste sources and producers. This is why the proposed policy options are presented under two main headings, one for food waste originating from the

household and the other for food waste originating from the food manufacturing and processing industry, retail and the food service sector.

Policy Options for Food Waste from the Household

Evidence Base	Engagement & Guidance	Implementation
<ul style="list-style-type: none"> • Determine quantity and detailed composition of food waste produced in the household, including percentage of avoidable and unavoidable fractions and individual food waste types (vegetables, salads, fruits, rice, bread, meat, fish etc.) • Understand the reasons behind food waste generations in the household (e.g. bad planning leading to too much food being bought, difficulties in understanding labels related to best before, consume by, sell by dates, incorrect storage at home, lack of cooking skills etc.) • Understand current practices around food and food waste and analyse practices of individual sub-groups according to number of variables, such as age, gender, income, family arrangements, religion etc. 	<ul style="list-style-type: none"> • Produce guidance on how households can prevent food waste (advice on shopping planning, leftovers cooking tips, portioning, storage and refrigeration, labelling etc.) 	<ul style="list-style-type: none"> • Gradually transfer the true cost of waste management back to the household, by increasing waste collection and management charges to cover the true cost of waste management and encourage prevention and minimisation • Reward waste prevention and penalise wasteful practices in monetary terms
<ul style="list-style-type: none"> • Identify barriers to waste prevention, food surplus re-use, recycling via composting and animal feed, and food waste segregation at source • Identify motivating factors that could drive waste prevention, food surplus re-use, recycling and food waste segregation at source e.g. cost saving, religion, community, environmental concerns etc. 	<ul style="list-style-type: none"> • Design communication campaigns, highlighting the financial, environmental and other merits of food waste prevention and simple tips of achieving this at the household 	<ul style="list-style-type: none"> • Reward waste minimisation and penalise wasteful practices in monetary terms
<ul style="list-style-type: none"> • Establish most suitable food waste collection systems for different types of housing (separate food waste collection vs. commingled food and green waste collection, collection frequency, most suitable receptacles for separate collections etc.) 	<ul style="list-style-type: none"> • Develop guidance on how households can compost and recycle food waste by turning into animal feed, and communicate the benefits of food waste minimisation. 	<ul style="list-style-type: none"> • Provide home composting bins and advise households on how to use them
<ul style="list-style-type: none"> • Identify most suitable methods for achieving the highest participation rates and highest yields for separate food waste collection • Calculate carbon emissions associated with food waste (throughout its supply chain, from agriculture, manufacturing, retail, consumption and final disposal) in Malaysia • Calculate the carbon emissions associated with food waste (throughout its supply chain, from agriculture, manufacturing, retail, consumption and final disposal) and the cost and carbon savings that be achieved through prevention, minimisation and landfill diversion of food waste by the households 	<ul style="list-style-type: none"> • Communicate the benefits of AD and the new separate food waste collection systems • Develop guidance on how households can separate their food waste and participate in the separate collection systems • Observe common mistakes and bad practices in separating food waste and continue advising households on how to improve • Monitor progress and adjust accordingly 	<ul style="list-style-type: none"> • Provide receptacles for separate food waste collections and advise households on how to use them

Policy Options for the Food Manufacturing and Processing Industry, Retail and the Food Service Sector

Evidence Base	Engagement & Guidance	Implementation
<ul style="list-style-type: none"> • Determine quantity and detailed composition of food surplus and waste produced and map out 'hot-spots' sources • Identify and map out demand for food surplus (third sector and community groups that could redistribute food to vulnerable and low income groups) and food waste (for recycling and energy recovery) • Examine current practices e.g. level of resource efficiency and whether any waste prevention, re-use, recycling, energy recovery and landfill diversion is being carried out. Identify best practice industry examples • Understand the reasons behind food waste at the individual industries • Understand factors that could drive prevention, re-use, recycling, energy recovery and landfill diversion e.g. cost savings, renewable energy generation, environmental concerns, marketing, 'green' image, corporate social responsibility, consumer demands etc. • Understand current barriers to waste prevention, re-use, recycling and energy recovery • Calculate the carbon emissions associated with food waste (throughout its supply chain, from agriculture, manufacturing, retail, consumption and final disposal) and the carbon and cost savings that be achieved by industry through food waste prevention, minimisation and landfill diversion in Malaysia 	<ul style="list-style-type: none"> • Produce industry specific guidance on how to prevent waste • Design industry specific communication campaigns, highlighting the economic, environmental and other merits of waste prevention and minimisation, and methods of achieving this. Use best practice examples and encourage replication across the industry • Engage with industry in order to develop voluntary waste prevention and minimisation agreements and guidance, paving the way for future mandatory requirements 	<ul style="list-style-type: none"> • Gradually increase waste collection and management charges to cover the true cost of waste management and encourage prevention and minimisation • Gradually introduce landfill tax to reward waste prevention and minimisation and penalise wasteful practices • Strengthen enforcement to avoid increase in fly tipping
	<ul style="list-style-type: none"> • Facilitate the development of food re-distribution networks by engaging with the third sector and community groups • Create links between food surplus sources and third sector • Produce industry specific guidance and standards on how to re-use food surplus through food redistribution schemes 	<ul style="list-style-type: none"> • Provide support to third sector and community groups involved in food surplus redistribution schemes
	<ul style="list-style-type: none"> • Facilitate the development of an 'industrial symbiosis' network connecting industries producing food waste/ by-products and industries in need of these by-products as alternatives to primary resources • Produce guidance and standards for the 'industrial symbiosis' network • Provide guidance and standards for either on-site composting for larger industries, or centralised composting from industries producing small amounts of food waste • Create links between composting facilities and food waste producers 	<ul style="list-style-type: none"> • Encourage growth of the composting market by using financial incentives and developing demonstration plants
	<ul style="list-style-type: none"> • Create links between food waste producers and AD facilities • Produce guidance and standards for AD on technology, digestate quality, applications for digestate on land etc. 	<ul style="list-style-type: none"> • Encourage growth of AD market by financial incentives, demonstration plants, including energy generation from AD plants into the existing feed-in tariff scheme

Recommendations for Further Studies

In the previous section, a number of policy options for food waste prevention and minimisation were presented. As stated in the methodology section of this report, these policy options emerged from a number of stakeholder engagement and knowledge exchange activities, drawing expertise from international successful examples of food waste minimisation. Therefore, this project's methodology is of a qualitative nature. Further studies are required to obtain quantitative data on food waste generation rates and sources in order to prioritise areas where policy can have the biggest impact. Quantitative data, as well as additional qualitative data on current practices, barriers, drivers for change and opportunities, can further inform the outcome of this project and are required for a comprehensive future policy on food waste minimisation in Malaysia.

Summary

This section provides a summary of the main points that emerged through this project. It highlights the key strategic and policy options for food waste minimisation in Malaysia.

Although food **waste prevention** requires a deep rethinking of the current approach, it can deliver the highest environmental, economic and social benefits in the long-term. Prevention should be the first option to deal with food surplus and the avoidable fraction of food waste, rather than technological fixes that can only address part of the problem.

After prevention has been exhausted as an option, other suitable food waste minimisation strategies include **re-use of food surplus**, **composting** and **recycling food waste as animal feed** and finally energy recovery via **Anaerobic Digestion**.

A solid and comprehensive **evidence base** is required to guide the policy formulation process and to prioritise and support its implementation. This includes data on food waste generation rates, composition, sources, as well as reasons behind food waste generation, current practices, barriers and drivers for waste prevention and minimisation.

Industry **voluntary agreements** for food waste prevention and minimisation, **industrial symbiosis networks**, **food surplus redistribution schemes**, industry specific **guidance and standards** can support food waste prevention and minimisation by the food manufacturing and processing, retail, food service and hospitality sectors.

Guidance and communication campaigns on how households can prevent food waste via better food shopping planning, storage and refrigeration, as well as improved cooking skills and re-use of food surplus can contribute to food waste minimisation from the household. Guidance and communication campaigns on composting and segregation of food waste at source are also required.

Policy implementation should be supported by a **mechanism rewarding food waste prevention and minimisation** and **penalising wasteful practice**. This can be achieved by gradually transferring the true cost of waste management back to the waste producers. Gradually introducing a disincentive to landfill, such as a landfill tax has the potential to drive food waste minimisation, however stronger **enforcement** is required to avoid increase in fly tipping.

Finally, the policy formulation and implementation process is iterative in nature, requiring continual reviewing and adjustment as new evidence arise. Thus, **longstanding commitment** and continuous effort is required to deliver long-term change towards a more sustainable solution to the food waste challenge in Malaysia.

References

Bender W. (1994) An end use analysis of global food requirements. Food Policy. Volume 19, Issue 4, Pages 381–395

Department for Environment, Food and Rural Affairs (Defra) (2011) Government Review of Waste Policy in England 2011. London

EC (2008) Waste Framework Directive 2008/ 98/EC of the European Parliament and of the Council. Strasbourg

European Commission (2006) Environmental Impact of Products (EIPRO): Analysis of the Life Cycle Environmental Impacts Related to the Final Consumption of the EU-25. Spain, Joint Research Centre (DG JRC), Institute for Prospective Technological Studies. EUR 22284 EN

Food and Agriculture Organization for the United Nations (FAO) (2010). Statistical yearbook 2010. Rome

Government of Malaysia (2007) Solid Waste and Public Cleansing Management Act. Act 672

Ministry of Housing and Local Government, Malaysia (2005) National Strategic Plan for Solid Waste Management. Malaysia

National Solid Waste Management Department (2010) Ministry of Housing and Local Government Malaysia. [Online] Available from: www.kpkt.gov.my [Accessed 10 February 2012]

Smil, V. (2004) Improving efficiency and reducing waste in our food system. Environmental Sciences Volume 1, Pages 17-26

Stuart, T. (2009) Waste. Uncovering the global food scandal. UK

United Nations Development Programme, Malaysia (2008) Developing a Solid Waste Management Model for Penang. Malaysia

United Nations Environment Programme (UNEP) (2008) Planning for Change: Guidelines for National Programmes on Sustainable Consumption and Production. France

Waste Resource Action Programme (WRAP) (2011) New estimates for household food and drink waste in the UK. Banbury

WRAP (2007). Understanding Food Waste: Key findings of our recent research on the nature, scale and causes of household food waste. Banbury

WRAP (2009). Household Food and Drink Waste in the UK. Banbury

WWF-UK (2006) Counting Consumption, Material Flows and Ecological Footprint of the UK by Region and Devolved Country. UK

Appendix B: Food waste minimisation report for case study 4

Food waste minimisation report for case study 4

by Universiti Teknologi Malaysia (UTM)

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10/20/2014

Executive summary

This report outlines the findings of a food waste assessment exercise undertaken at the Case study 4 Hotel, Malaysia, during May 2014. The amount and type of food waste, as well as the reasons behind food waste generation by Case study 4's food service operations are recorded and discussed, followed by recommendations on how to achieve waste prevention in order to cut costs and improve the sustainability performance of Case study 4.

The study revealed that Case study 4 produces on average 173kg of food waste per day, equivalent to 62 tonnes of food waste per year. It also estimated that 30% of the food purchased is lost in the form of food waste, equating to an average annual loss of RM290,411. One of the key findings of the study is that food waste generated during the preparation stage is the largest source of food waste, followed by food waste in the form of buffet leftover and leftovers from the customers' plate. The majority of customer plate leftover and buffet leftover waste is rice and noodles, followed by desserts and fruits.

Reasons behind preparation food waste generation included excessive cuttings for aesthetic reasons, limited reuse of cuttings, leaves, stalks etc. in other menu items, fruit going off, over production and over cooking of rice leading to rice stuck at the bottom of the cooking pans. Reasons behind buffet leftover food waste generation included, the 'no food on the buffet for more than four hours' policy, over production, difficulty in estimating the correct customer numbers due to lack of booking customer culture, and overestimating of portioning per person at buffet functions. Finally, reasons for customer plate leftover food waste generation included, over ordering and not asking for leftover food to be wrapped up for take away in the case of a la carte service. In the case of buffet service, customers 'trying out' all buffet items and taking more than they can eat, led to customer plate leftover waste. These attitudes are linked to a misjudged notion of 'value for money', prioritising quantity over quality.

As part of the proposed food waste prevention strategy, recommendations for food waste prevention are provided in detail within this report. The recommendations can broadly be grouped into the following categories: training of staff, changes in menu design and portioning, enhancement of communication and management, standardisation of procedures and introduction of incentives for behaviour and practice change. A concept crucial to the success of the strategy is that food waste should be considered throughout all the stages of Case study 4's operations not just in the kitchen. In addition, the cooperation of all staff is central to the implementation of the food waste prevention strategy and this should be achieved by actively seeking staff

engagement and participation. Finally, with the right strategy and implementation, food waste prevention can offer significant cost savings, environmental and social benefits, as well as contribute to Case study 4's ambition to become the most sustainable hotel in Malaysia.

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Introduction

Project background

Case study 4 Hotel is part of the international hotel chain of Shangri-La and offers the high service and quality standards associated with the brand name. It consists of 118 guest and suites, banquet facilities and four restaurants and bars, namely ██████████ ██████████ bar. Case study 4 aspiration to become a more sustainable hotel led to the collaboration between Case study 4 and Universiti Teknologi Malaysia (UTM) under a research project looking into the issue of food waste in order to identify opportunities for waste prevention. This report is the output of this collaboration.

Project aim

The aim of the project is to identify opportunities for food waste prevention within Case study 4 operations, by measuring food waste quantities and types, identifying the processes that give rise to food waste and understanding the reasons behind food waste generation.

Project objectives

The main objective of the study is to carry out a food waste assessment at Case study 4 food service in order to establish a baseline, which is turn will inform the food waste prevention strategy of the hotel. The food waste assessment included:

- measuring food waste generation;
- identifying the processes that give rise to food waste;
- understanding the reasons why food waste is generated; and
- recommendations on how to prevent food waste, in order to cut costs and increase the sustainability performance of Case study 4.

More details related to the methodology used are presented in the following section.

Project scope

For the purpose of this project, the scope was set to include the operations associated only with ██████████ Café restaurant, as this is the main food service establishment within the hotel, serving breakfast, lunch and dinner in a combination of buffet and a la cart service.

Background on food waste

Before going into the details of the project, the following paragraphs give a brief background to food waste and outline the key impacts associated it.

What is food waste and what are the impacts associated with it?

For the purpose of this study, food waste is defined as wholesome edible material intended for consumption by Case study 4's customers, arising at any point within Case study 4's operations, from the purchasing to the consumption stage that is instead discarded, lost or degraded.

Food waste has environmental, social and economic impacts. The environmental impacts of food waste are linked to the greenhouse gases emitted during all the previous stages of food production (from agriculture, to processing, to retail, to consumption), as well as during its final disposal in landfills. Other environmental impacts of food waste include natural resources depletion (such as soil nutrients, water and energy) and air, water and soil pollution potential throughout the food supply chain, but particularly during waste disposal. The social impacts of food waste tend to focus around the ethical and moral dimensions of wasting food, and in particular in relation to the inequality between on one hand wasteful practices, and on the other food poverty. Finally, the economic impact of wasting food is felt by businesses in purchasing of fresh produce and food supplies that will be later wasted, and in disposal costs of the food waste itself. The Sustainable Restaurant Association states that food waste costs UK restaurants approximately two to three per cent of their turnover.

What is sustainable food surplus and waste management?

According to the 'Waste Hierarchy' described in the European Waste Directive (Figure) and Malaysia's broader solid waste management policy framework based on the 3Rs concept of Reduce, Re-use, Recycle, this study proposes the following options for sustainable food surplus and waste management.

- **Prevention:** Food waste prevention can deliver the most advantageous environmental, social and economic benefits, thus it is the preferred option. Food waste prevention can be achieved by avoiding the generation of food surplus throughout the food production and consumption cycle.
- **Re-use:** Once all the efforts for prevention have been exhausted, re-use of edible surplus food for human consumption is the next best option. This requires an organised and sophisticated collection and redistribution system in place, ensuring food safety and safeguarding against commercial liabilities and conflict of interests.
- **Recycling:** Food surplus that is not fit for human consumption can then be recycled either by becoming animal feed or by being composted to produce soil conditioner.

- **Energy recovery:** Unavoidable food waste can be treated with Anaerobic Digestion (AD) technologies to generate energy in the form of biogas, and soil conditioner in the form of digestate.
- **Disposal:** The last option for the remaining fraction of unavoidable food waste is disposal. Disposal should however be in the form of fully engineered, sanitary landfills with landfill gas utilisation systems in place.

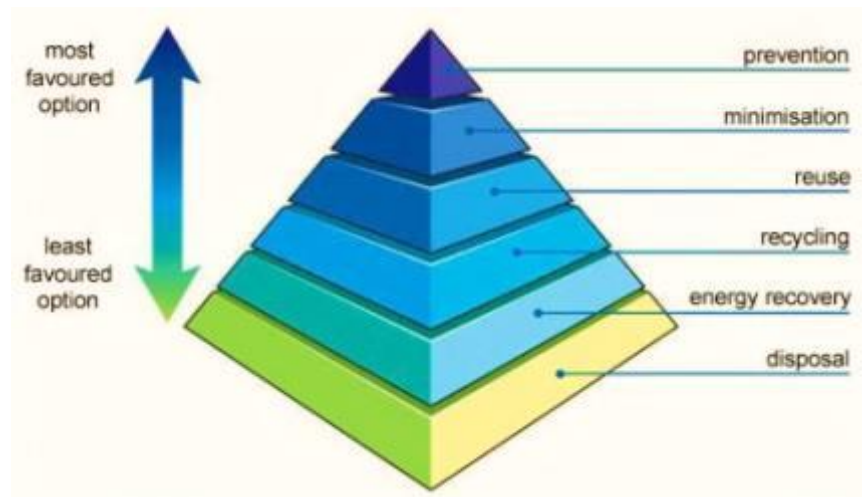


Figure 1: Waste hierarchy

Project methodology

The methodology selected for this project involved both quantitative and qualitative data collection and analysis. It comprised a food waste assessment, visual observations of current practices and behaviours, photographic records and informal discussions with members of staff.

The data collection process was carried out over one week beginning on 02 May 2014 and ending on 08 May 2014. Three UTM research staff assisted in the data collection period including the Project Leader Effie Papargyropoulou, and research officers





Figure 2: Scale measuring the weight of preparation waste and recording of food waste bin weight by research officers

The food waste assessment covered the operations at the [REDACTED] cafe. Six kitchen / food preparation areas and their respective washing areas were monitored, including the butchery, the pastries area, the western kitchen, the cold kitchen, the Asian kitchen and the [REDACTED] kitchen.

During the food waste assessment, the amount and type of food waste were identified. The amount of food waste generated was measured and recorded daily. Three types of food waste were recorded:

- 'preparation waste': produced during the food preparation stage, due to overproduction, trim waste, expiration, spoilage, overcooked items, etc.
- 'customer plate leftover waste': food discarded by customers after the food has been sold or served to them
- 'buffet leftover waste': excess food that has been prepared but has not been taken onto the customer's plate or consumed, thus left on the buffet or a food storage area (in the chiller or warmer)

These three types of food waste were recorded and linked to a specific type of meal (i.e. breakfast, lunch or dinner). This allowed conclusions to be drawn about the most wasteful eating times and the food types that contribute to the wastage.

In addition to the amount of food waste generated, in-situ estimates of the edible fraction of food waste were made based on visual observations. Suggestions for the reasons that lead to the wastage were also recorded.

The researchers also observed the day to day activities associated with the operations and collected useful qualitative information, adding extra layers of detail to the complex issue of food waste generation.



Figure 3: Views of the lunch time buffet at Palm hill cafe

Finally, official meetings and casual discussions with the operational/ kitchen staff, the purchasing and the management team were carried out gaining a better understanding of the operations. These exercises aimed at obtaining and analysing the views of the management and employees regarding food waste, and in more detail where and why food waste is generated, and where the opportunities for waste prevention lie.

The data collected from these three methods were analysed qualitatively and quantitatively to draw tangible conclusions about food waste generation and inform the food waste prevention strategy for Case study 4.

Limitations

The timescale for this project was limited for funding-related reasons, therefore it is recognised that additional monitoring would greatly add to the outcomes of this study. Efforts were made to select a 'typical' week to monitor, following the advice of the Executive Chef and based on the event bookings for these weeks. In addition, monitoring during other times of the year would limit potential discrepancies caused by variations that occur throughout the year.

It is likely that not all food waste generated during the time of the survey was captured and recorded. However, the research team is confident that the 'capture' rate is close enough to the actual food waste generation and sufficient for the purposes of this exercise.

Finally, it is recognised that the presence of the UTM research staff within the Case study 4's food preparation areas, might have had an impact on the behaviour of the operational staff, in that staff would deviate from their usual behaviour and practices to

'please' the researchers and present an artificially positive 'picture' of the typical operations. This phenomenon is often referred to as 'reactivity', as in the influence that being observed has on behaviour. The research team made efforts to limit the impact of 'reactivity' by applying the technique of 'habituation', i.e. allowing the subjects to become familiar with the process of observation so that they take it for granted.

Findings

In this section, the findings of the study are presented and discussed, feeding into the proposed strategy for food waste prevention outlined in Section 4.

Daily food waste generation

The amount of food waste generated from ██████████ café is presented in the paragraphs and tables below. Food waste is broken down into preparation waste, buffet leftover and customer plate leftover waste. The average daily amounts of these three fractions and the total daily food waste amount per operation are also calculated.

Palm hill café

The food waste generated by ██████████ café during the week between 2nd and 8th of May 2014 is presented in Table 1.

On average **173.2kg of food waste per day or 1,212.4kg per week** is generated by the operations linked to ██████████ café.

Preparation waste is the largest fraction of food waste, followed by waste from the customers' plate and finally by buffet leftover waste.

A noticeable variation in the daily amount of food waste can be observed, and this does not always correlate to the number of customers served per day. For example, Tuesday appears to have the second highest amount of food waste, while more customers were served on Saturday, Monday and Thursday. This 'apparent anomaly' can be explained by the fact that a lot of the food preparation (and subsequently generation of preparation food waste) happens the day before, not on the actual day of a given event (e.g. on Tuesday some preparation was made for Wednesday's buffet). This example demonstrates how food waste generation from the buffet operations is highly dependent on the types of individual events and functions taking place every day.

Table 1: Daily food waste generation by the operations linked to Palm hill café

	Fri 2 May 2014	Sat 3 May 2014	Sun 4 May 2014	Mon 5 May 2014	Tue 6 May 2014	Wed 7 May 2014	Thu 8 May 2014	Daily average
Customers served per day	101	193	89	161	148	295	243	176
Preparation waste (kg)	62.5	78.1	72.5	101.5	138.7	136.2	78	95.2
Buffet leftover(kg)	40.6	54.6	22	13.3	44.7	41.4	34.1	37.9
Customer plate leftover (kg)	16.4	46.6	54.6	31.3	34.5	47.3	49.9	40.1
Total food waste (kg)	118.5	179.3	149.1	160.6	217.9	224.9	162	173.2

Extrapolating from this average daily rate of food waste generation suggests that in **one year Case study 4 generates in the region of 63 tonnes of food waste.**

Table 2: Daily food waste generation by type of meal time

	Breakfast	Lunch	Dinner	Average daily waste (kg)
Customer numbers	46.6	85.1	44.0	
Preparation waste (kg)	29.1	44.0	22.1	95.2
Buffet leftover(kg)	15.1	23.5	18.8*	37.9
Customer plate leftover (kg)	14.7	10.1	15.3	40.1
Average daily waste (kg)	58.8	77.6	56.2	173.2

*buffet leftover average for dinner is based only on the Saturday dinner BBQ night, as for the rest of the days dinner was a la cart.

Preparation waste is the largest contributor to the overall figure followed by customer plate leftover waste and then by buffet leftover. However, these figures can be misleading, in that they suggest that buffet leftover is less than customer plate waste. This is only due to the fact that dinner time meals were mainly served as a la cart producing no buffet leftovers. A more representative picture is drawn in Table 3, where the percentage breakdown of the different food waste fractions are presented for the three meal times (breakfast, lunch and dinner). Preparation waste is the largest percentage for all three meal times, buffet leftover and customer plate waste is the

same for breakfast, buffet leftover is double the customer plate waste for lunch and higher than customer plate waste for dinner.

Table 3: Percentages of preparation, customer plate and buffet leftover waste fractions for the three meal times (breakfast, lunch and dinner)

	Breakfast	Lunch	Dinner
Preparation waste	50%	57%	39%
Buffet leftover	25%	30%	34%*
Customer plate leftover	25%	13%	27%
	100%	100%	100%

*buffet leftover for dinner is based only on the Saturday dinner BBQ night, as for the rest of the days dinner was a la cart.

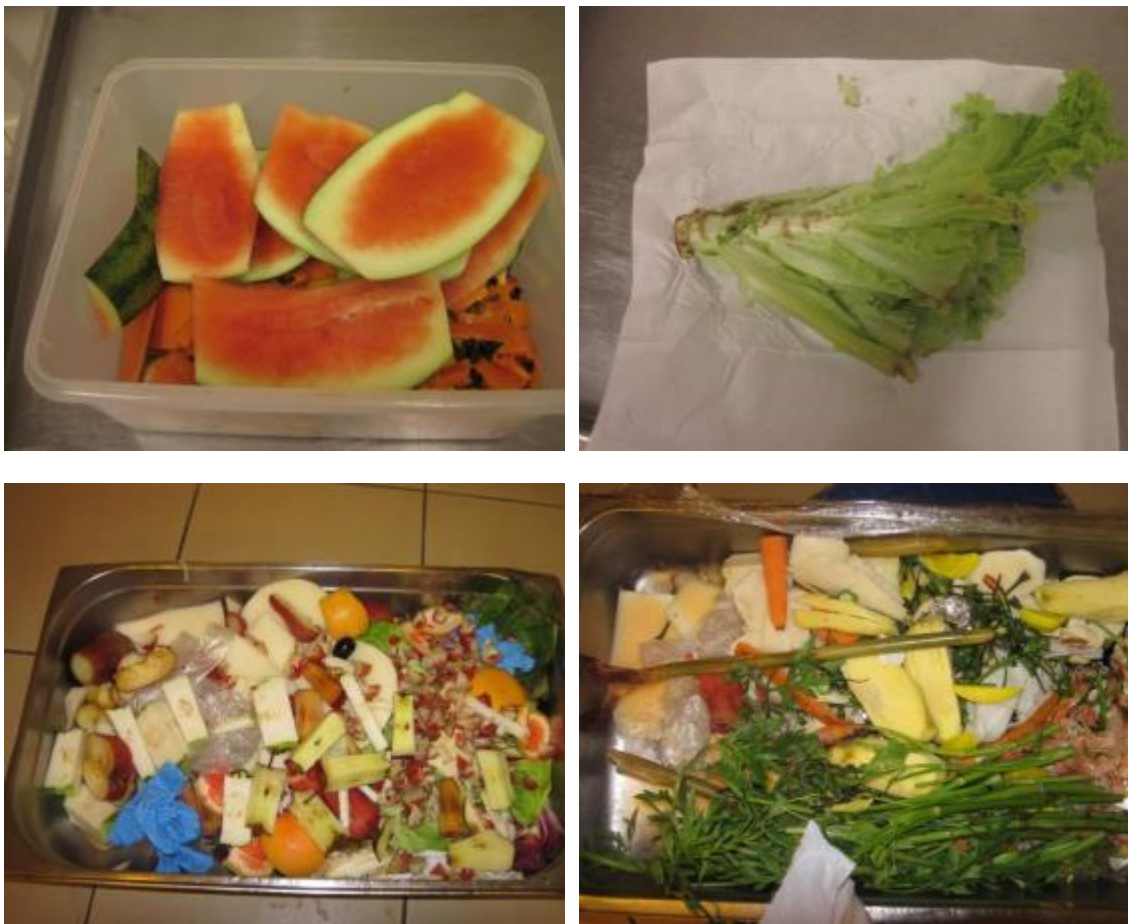


Figure 4: Examples of preparation waste

Average food waste generation per customer served

Table 4 shows the average food waste generated by [redacted] café per customer served. These figures can serve as a benchmark for the relative food waste generation, regardless whether many or only a few customers were served on a particular time.

These figures suggest that the lunch time meal has the highest food waste per customer rate at 1.28kg of food waste per customer, followed closely by breakfast at 1.23 kg per customer, and dinner at 1.18 kg per customer. This can be explained by the high buffet leftover waste per customer observed during lunch, at 0.39kg per customer. The lower rate of waste generation per customer during dinner can be explained by the fact that there was only one evening when a buffet was offered, whereas the rest offered only a la cart service. These findings highlight the wasteful nature of buffets compared to the a la cart service style.

Table 4: Average food waste generation per customer served

	Breakfast	Lunch	Dinner
Preparation waste per customer served (kg/person) *	0.60	0.60	0.60
Customer plate leftover waste per customer served (kg/person)	0.30	0.29	0.37
Buffet leftover waste per customer served (kg/person)	0.33	0.39	0.19
Total daily waste per customer served (kg/person)	1.23	1.28	1.18

*preparation waste was measured daily as a total and it was not possible to distinguish between the different meal times. Therefore, the total daily preparation waste was proportionally distributed between breakfast, lunch and dinner according to customer numbers.

Financial implications

According to the analysis of incoming food and the outgoing food waste, it is concluded that approximately 30% of purchased food is lost in the form of food waste. In more detail, approximately 17% of food is lost during preparation, 7% as customer plate waste and 6% as buffet leftover waste (Figure 5). Assuming an average monthly food cost of RM80,000, the 30% of food loss equates to RM24,201 lost every month and an annual loss of RM290,411.

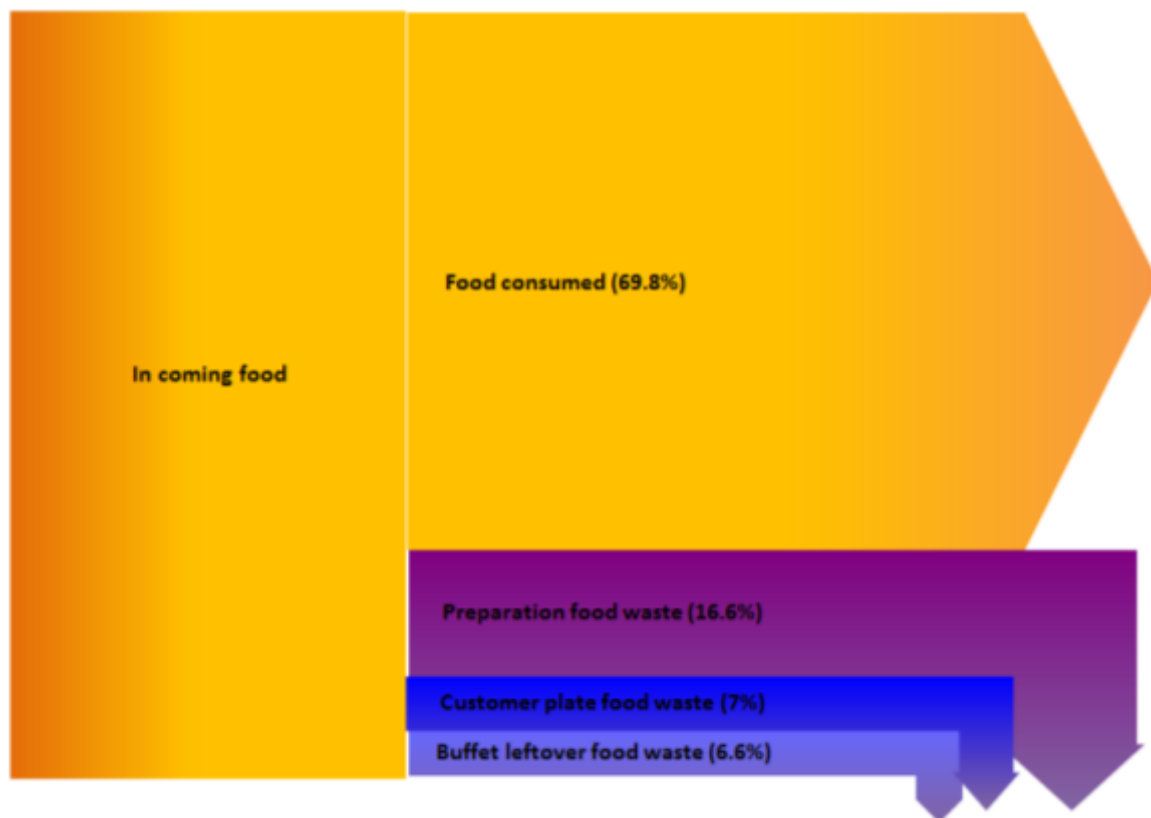


Figure 5: Materials flow diagram for Palm Hill Café

Re-use of food surplus

No official re-use of surplus food waste observed [redacted] café operations. The official ‘no food stays out on the buffet longer than 4hours’ Shangri-La policy prevents from any such re-use methods.

Unofficially and in very rare cases leftover food returning from the lunch buffet, was ‘diverted’ from going into the waste bin before being washed, by staff for their own consumption. It is not clear how common or uncommon this practice is, as the researchers sensed the staff were potentially altering their behaviour during the study period.

No examples of reducing preparation waste by using cuttings and trimmings into other menu items were observed (see Figures 9, 10 and 11 for proposed examples).

Most wasted items

Based on observations during data collection, the food items most commonly wasted are rice, noodles, cakes and desserts, and fruits (Figures 6, 7 and 8).

Rice and noodles contributed considerably in both buffet, customer plate leftover waste. Rice contributed to preparation waste, as there were instances when over production or rice stuck at the bottom of cooking pans lead to considerable waste.

Cakes, desserts and fruits contributed significantly to food waste generation in the form of buffet leftovers. Fruit waste also appeared in the form of preparation waste due to a number of reasons including:

- skins and/ or cores from fruits such as watermelons, melons, mangos, pineapples etc. are heavy and they were mainly inedible fractions being wasted, therefore there is not much scope for reduction
- elaborate designs when using fruit as part of plate decoration that required a large portions of the edible part of the fruit to be wasted in order to achieve the desired shape, and
- spoilt, overripe or bruised fruits not used on time
- overproduction of certain dishes such as rice, sauces and types of curries. In the case of rice, sticking at the bottom of the cooking pan is one common contributor to preparation waste



Figure 6: Examples of rice and sauce overproduction contribute to preparation waste. Rice stuck at the bottom of cooking pans was another common source of avoidable waste during preparation



Figure 7: Overripe bananas not used on time (left), dessert fruit tarts before (right)



Figure 8: Fruits significantly contribute to preparation waste due to presentation requirements

Broader issues effecting food waste generation

As part of this study, observations of the general procedures and practices outside the kitchen were made to form a fuller picture of the Case study 4 operations. A number of issues and factors effecting food waste generation were identified and described below in the form of examples that generated excessive amounts of food waste. These issues are discussed and suggestions are included on how small changes in current practices could lead to food waste reduction.

Buffet versus a la cart

The analysis of the data collected suggests that dinner was the least wasteful meal time, followed by breakfast. Lunch was the most wasteful meal time of all. These comparisons reveal that the type of service provided (buffet versus a la cart) has a significant impact on the amount of food waste produced. Buffet style service is actually more wasteful than a la cart.

Pre-booking versus walk-ins

When looking at buffet service in particular, a parameter that affects waste generation is how accurate the prediction of the customer numbers is during food preparation. In other words, if food is prepared for the actual number of customers being served, then food waste can be minimised. In order to get this balance, booking is crucial. This is the reason why the breakfast buffet is less wasteful than the lunch buffet. Because [REDACTED] café offers breakfast to the visitors at the hotel, the numbers of the actual customers having breakfast deviate only marginally from the bookings. During lunch time, a larger percentage of customers are 'walk-ins', making the process of estimating the numbers to prepare food for, a lot more difficult.

'No food on the buffet for more than 4 hours' policy

In order to adhere to the high standards of quality set by the international brand name, Case study 4 has in place a policy specifying that food items should not be left on the buffet for longer than 4 hours. For example, if a dish is served during the lunch time buffet and it is not consumed, it cannot be 're-used' during dinner time and has to be discarded. This leads to significant amounts of buffet leftovers.

Summary of key findings

In this section bullet points of the study's key findings are presented.

- **████████ café produces on average 173kg of food waste per day**
- **████████ café produces on average 62 tonnes of food waste per year**
- **Preparation waste is the largest source of food waste**, followed by buffet leftover waste and the customer plate leftover waste (as expressed in percentages)
- Of the three meal times **████████ café lunch has the highest rate of overall food waste per customer with 1.28kg** of food waste generated for every customer being served, followed by breakfast with 1.23 kg per customer, and finally dinner with 1.18 per customer.
- Majority of edible **customer plate leftover and buffet leftover** waste is **rice and noodles**
- Following rice and noodles, **desserts and fruits** are some of the most wasted food items
- **Reasons for preparation food waste** include:
 - a. overproduction and over cooking (e.g. rice stuck at the bottom of cooking pans)
 - b. excessive cuttings for aesthetic reasons
 - c. limited reuse of preparation waste such as cuttings, leaves, stalks etc. in the creation of other menu items
- **Reasons for buffet leftover food waste** include:
 - a. limited booking practice and high walk-in rates, making planning difficult
 - b. overestimate of portioning per person especially for rice and noodle items
 - c. 'no food on buffet for more than 4 hours' policy

- **Reasons for customer plate leftover food waste** include:
 - a. in the case of a la carte service, over ordering and not asking for leftover food to be wrapped up for take away
 - b. in the case of buffet service, customers 'trying out' all buffet items and taking more on their plate than what they can eat. These attitudes are linked to a misjudged notion of 'value for money', prioritising quantity over quality

Recommendations for food waste prevention

In the previous sections, the hot spots of food waste generation and some of the factors giving rise to food waste generation were presented and discussed based on the findings of the food waste audit carried out. Based on these findings, recommendations for food waste prevention tailored to Case study 4 are presented in this section. The recommendations are organised in 3 sections according to the type of food waste they tackle, beginning from the larger food waste source i.e. preparation waste, followed by the subsequent food waste types of buffet and customer plate leftover waste.

Preparation food waste

As the food waste audit demonstrated, food waste generated during food preparation is the largest food waste sources of ██████████ café's operations (refer to Table 2). As such, it should be considered as a priority in the food waste prevention strategy.

In response to the main factors leading to food waste during the preparation stage, the following measures are proposed to help reduce preparation food waste:

- Provide training, supervision and guidance on more efficient peeling, cutting and trimming techniques (e.g. knife skills) especially to less experienced kitchen staff. Make this type of training compulsory and repeat on regular basis. Combine formal training with on the job training and guidance so that it becomes standard practice, not to be seen just as extra workload, but something to be proud of.
- Eliminate items on menu that require excessive cutting for aesthetic reasons or ensure cuttings are utilised within the same food item
- Use preparation waste such as cuttings, peel and trimmings in the creation of other dishes (turning orange peel into marmalade and pickles, using vegetables and herbs stalks for soup etc. see suggested examples in Figures 9, 10 and 11)

- Maximise preparation waste reuse by making it standard practice, not just ad-hoc practice.
- For large group bookings, implement a strict no changes policy during the week prior to the event. The customer should be made aware of this policy when placing the booking. In addition, it should be communicated that this policy is in place in order to ensure the high standard of quality service provided by Case study 4.
- Avoid over production and overcooking especially with rice to reduce food being stuck at bottom of cooking pans and contribute to preparation waste



Figure 9: Example of using preparation waste in the creation of other dishes: use of bread crust generated during preparation for sandwiches into bread and butter pudding



Figure 10: Example of using preparation waste in the creation of other dishes: use of vegetable peels and stalks into soups



Figure11: Example of using preparation waste in the creation of other dishes: use chicken and fish cuttings to make chicken and fish stock respectively

Buffet leftover food waste

In response to the main factors leading to food waste in the form of buffet leftover, the following measures are proposed to help reduce buffet leftover food waste:

- Avoid preparing scrambled eggs as a breakfast buffet item. Instead have an 'egg station' where each customer can choose the type of egg dish they would like to order.
- For large group bookings, implement a strict no changes policy during the week prior to the event. The customer should be made aware of this policy when placing the booking. In addition, it should be communicated that this policy is in place in order to ensure the high standard of quality service provided by Case study 4.
- For large group bookings, improve communication between the sales department and the kitchen staff regarding the client's requirements and any changes on numbers or meal times.
- Encourage bookings for the lunch buffet and discourage walk-ins (e.g. 10% discount for booking, compared to walk-in price)
- Reduce the portion size prepared per customer especially for rice and noodle items.
- Divert food surplus generated by the buffet due to the '4 hours policy' to the staff canteen. Market this as a staff 'perk' and as part of the company's efforts to provide a good working environment for its staff. This practice will further reduce food waste and costs.
- Introduce an official system where at the end of each day, any buffet leftovers that need to be consumed within that evening are made available to staff to

take home. This system would require to comply with health and safety standards and be linked to a no liabilities clause for Case study 4.

- An alternative option to allowing buffet leftover food to be consumed by staff, is to establish a food recovery scheme, where leftover food is packaged and diverted to people affected by food poverty, through charities and or /NGOs. A scheme like this will require to comply with health and safety standards and be linked to a no liabilities clause for Case study 4.
- Reuse buffet leftover fruits or fruit cuttings from food preparation to make smoothies, sorbet, milkshakes etc. to offer as 'specials of the day' or use them in desserts (Figure).
- Produce individual cakes and desserts rather than big trays of puddings for buffet use.



Figure12: Example of buffet leftover waste in the creation of other dishes: use of leftover fruits (while still fresh) into smoothies and other types of fruit drinks and have these items as “specials of the day”

Customer plate leftover food waste

In response to the main factors leading to food waste from the customers' plate as, the following measures are proposed to help reduce customer plate leftover food waste:

- For a la carte service, update the menu so that it explains to the customer the size of each food item giving advice if it is suitable for one person or for sharing between more than one. Train the waiters to give advice to customers on amount of food ordered and to discourage over ordering. Make this advice part of standard practice.
- For a la carte service, train waiters to offer wrapping leftover food for customers to take home and encourage the customers to take up this option. Make this part of standard practice.

- For buffet service, provide small 'tasting stations' at the front of each buffet item, so that customers have the option to initially take on their plate 'sampling portions' before coming back for more of their favourite items.
- Have chefs stationed next to food items offering advice to the customers about the dishes, their ingredients and flavours.
- Studies have shown that reducing the size of the plates discourages customers from over piling their plate with buffet items.
- Incentivise food waste prevention and change in behaviour by offering a discount to customers producing no food waste.

Conclusions

This study measured the amount and type of food generated at Case study 4, including the breakfast and lunch buffet, and the dinner time a la cart service at ██████ café. It revealed that ██████ café produces on average 173kg of food waste per day. Three types of food waste were recorded, preparation waste, buffet leftover waste and customer plate leftover, over the period of one week. Continuous observation and discussions with Case study 4 staff offered data of qualitative nature adding another layer of understanding of food waste generation and the reasons behind it. The data analysis exercise helped identify the hot spots of food waste generation and the factors affecting it, and hence guide and prioritise the proposed food waste prevention strategy for Case study 4, as discussed in Section 0.

One of the key findings of the study that 30% of the food purchased is lost in the form of food waste, equating to an average annual loss of RM290,411. The study revealed that preparation waste is the largest source of food waste, followed by buffet leftover and finally customer plate leftover food waste. This suggests that the food waste prevention strategy should focus first at the preparation stage, and secondly at the buffet operation and consumption stage. Continuous training of kitchen staff especially on knife skills is essential to reduce preparation waste. It is also crucial that all staff are fully engaged in and understand the food waste prevention strategy, in particular the costs associated with food wastage and the benefits of waste prevention. This will ensure food waste prevention becomes a common goal of both the management and the operational staff and finally become standard practice and a common culture. Engagement and training of all other staff working in purchasing, sales and customer facing positions is also essential to the food waste prevention strategy, especially in reducing customer and buffet leftover waste.

As a final point, food waste prevention should be considered throughout the different stages of the operations (Figure 13): starting at the point of purchasing of food supplies, at the sales department while making and managing bookings, to the management and monitoring of the food supplies storage, to the actual food preparation and management of mise en place, to the portioning of food on plates and final disposal. By tackling food waste throughout the different stages of the operations, food waste prevention is possible and can offer not only substantial cost reduction, but also contribute to Case study 4's ambition of becoming the leading sustainable hotel in Malaysia.

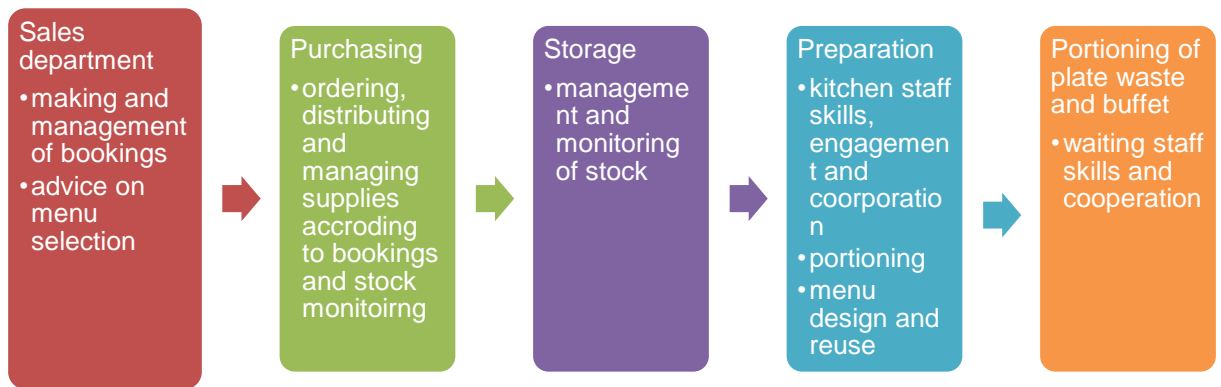


Figure 13: Food waste prevention throughout all the stages of Case study 4's operations