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

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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

1 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 (see 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; Edwards and Mercer, 2007; Evans, 2014; Papargyropoulou et al., 2014). In addition, food waste has predominately been studied either through quantitative (see Beretta et al., 2013) or qualitative (e.g. 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 2 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 explains how these tools, methods and research strategies have been applied within the framework. In Section 4 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 4. Finally, the conclusions and the implications of the paper are presented in Section 5.

2 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 Flows 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, 2011). 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, 2003). 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 (Huppes 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 (Seppäläa 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, 2011; Goonan et al., 2014; Gregson et al., 2013; Hetherington, 2004). In these studies a mixture of data collection methods were 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; (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, 2007a). 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, 2007b). 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, 2011), and household energy consumption (Sahakian and Steinberger, 2011). Some studies (e.g. Martin et al., 2006; Padfield, 2011; Quested et al., 2011) 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, 1967). 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.

2.1 Definitions of food waste

The FAO 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) (FAO, 2014). 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; and (ii) 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).

2.2 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; Evans, 2011; Evans et al., 2013; Graham-Rowe et al., 2014; Quested et al., 2011) (

Figure 1). 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 1, is designed to happen concurrently to the actual data collection and analysis process.

Figure 1 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.

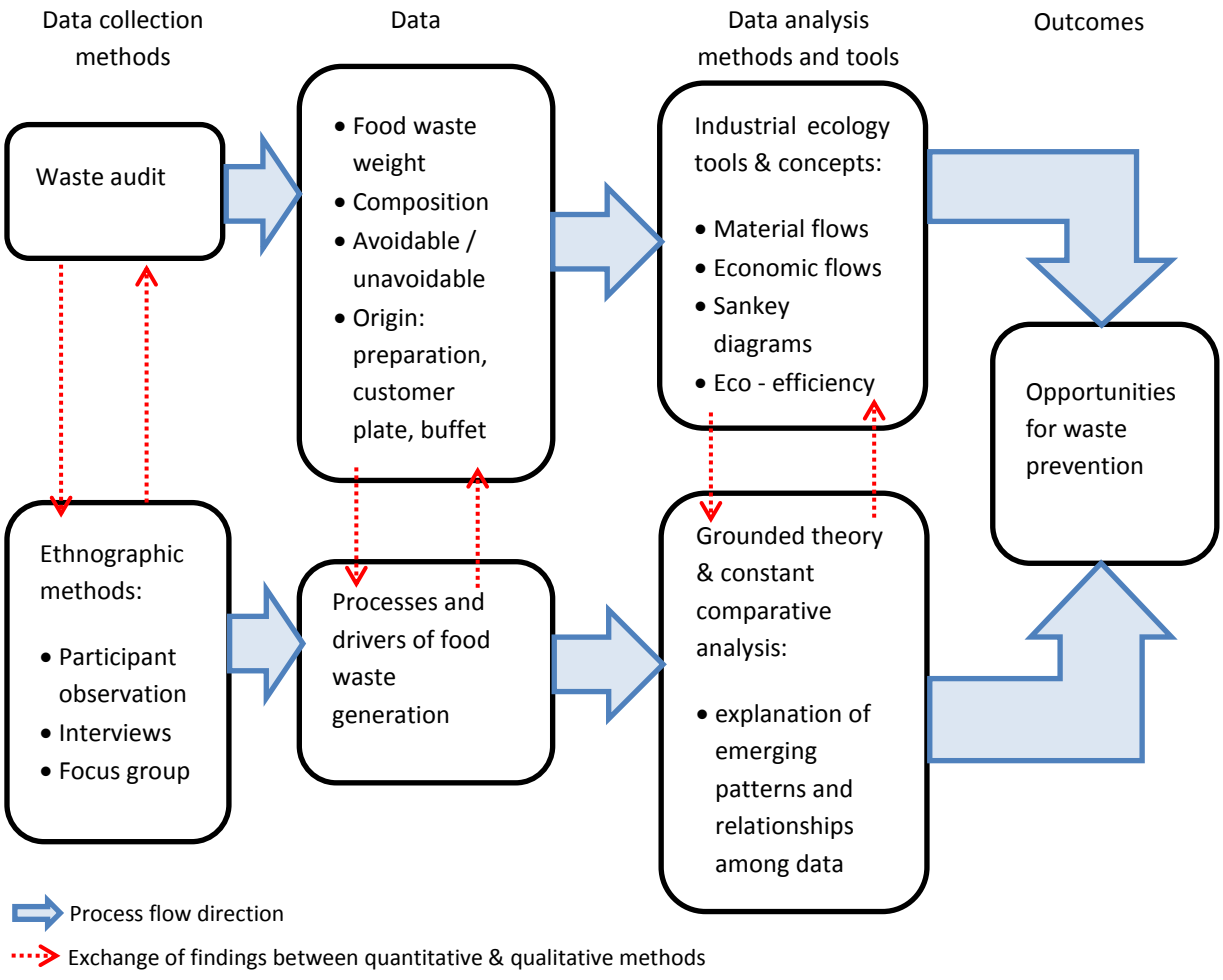


Figure 1: Conceptual framework for the study of food waste generation and prevention in the hospitality sector

3 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.

3.1 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, overcooking, 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 1.

Table 1: Food commodity groups used in this study to categorise incoming food and waste

Food commodity category	Type of foods included in category
Cereal	Rice, pasta, noodles, bread, floor, 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

Adapted from (Gustavsson et al., 2011)

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 Malaysia[1] (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.

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

3.3 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

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

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, 1967). 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.

4 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 6.30am – 11.00pm, 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.

4.1 Food waste generation patterns and drivers

On average 173kg of food waste per day was generated by the restaurant's operations (see Table 2). As described in the methods section, food waste was divided into preparation waste, buffet leftover and customer plate leftover waste..

Table 2: 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 average**	**Stand. deviation**
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	16.4	46.6	54.6	31.3	34.5	47.3	49.9	40.1	13.4

(kg)									
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**

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 (1.37kg 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."

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 3. 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

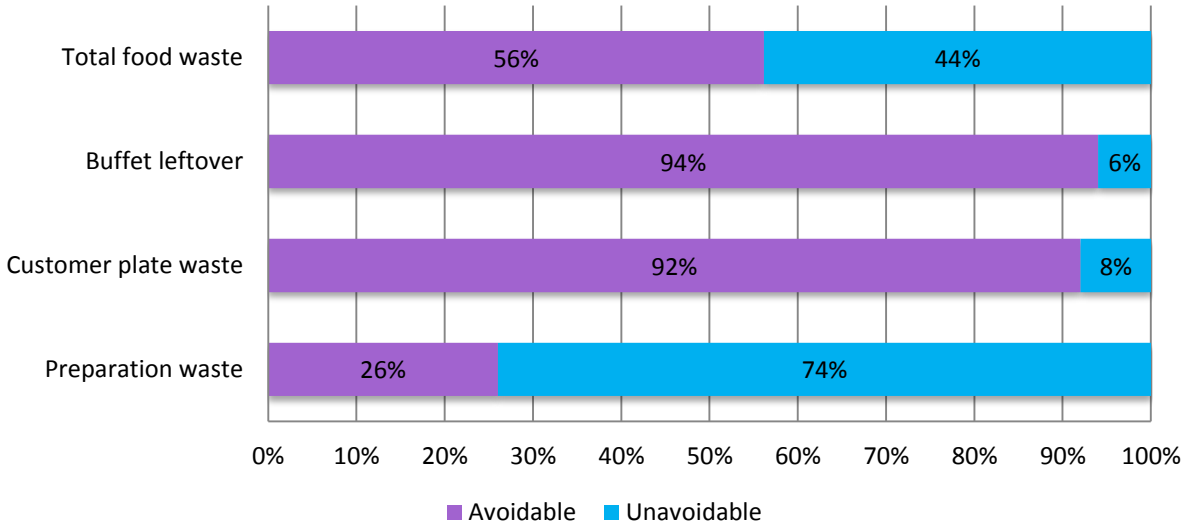
lunch time buffet with 1.1kg per customer and dinner time buffet and 'a la carte' service, with 1kg per customer. If the outlier of the lunch time 'a la carte' meal was excluded, the figures suggested that buffet style service was overall more wasteful than 'a la carte' service. Buffet service had lower 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.

Table 3: 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**

The patterns from the data in tables 2 and 3 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 lead 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.

Another important feature of food waste generation was the percentages of avoidable and unavoidable fractions of food waste. As Figure 2 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 as well (2013).



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406 Figure 2: Avoidable and unavoidable food waste fractions of food waste

407 The next step to the analysis involved the generation of three Sankey diagrams illustrating the
408 economic and material flows from food provisioning to food consumption. According to the analysis
409 of incoming food and the outgoing food waste, it was calculated that approximately 30% of
410 purchased food was lost in the form of food waste (no re-use of surplus food waste was observed in
411 this case study) (see Figure 3). In more detail, approximately 17% of food was lost during
412 preparation, 7% as customer plate waste and 6% as buffet leftover waste. The total food waste rate
413 was higher than the average 20% reported by Beretta et al (2013), however lower than the maximum
414 food loss they encountered during their study, of 45% at a gourmet restaurant. In Figure 3 the liquid
415 fraction was included within the incoming food, food consumed and food waste and it was not
416 shown separately. Meat and dairy represented 10% and 8% of incoming food, however only 1% and
417 0.2% of these food commodities respectively left the restaurant in the form of waste (see Figure 4).
418 However, vegetables, cereal and fruit represented the three most wasted food commodities. These
419 results corresponded to visual observations of the most commonly wasted food items, these being
420 rice, noodles, cakes and desserts, as buffet left overs and customer plate waste, and fruit and
421 vegetables as preparation waste. They also corresponded with reports by other studies (Betz et al.,
422 2015).

423 Figure 5 shows the economic flows that took place within the restaurant, broken down in the nine
424 food commodity groups. This graph provides a different perspective to the previous graphs. It shows
425 that although the liquid fraction was the most significant waste component in terms of weight (55%
426 of total waste) it was not significant in economic terms. In contrast, cereal, vegetables, fruits, fish and
427 seafood were the biggest economic losses of the system.

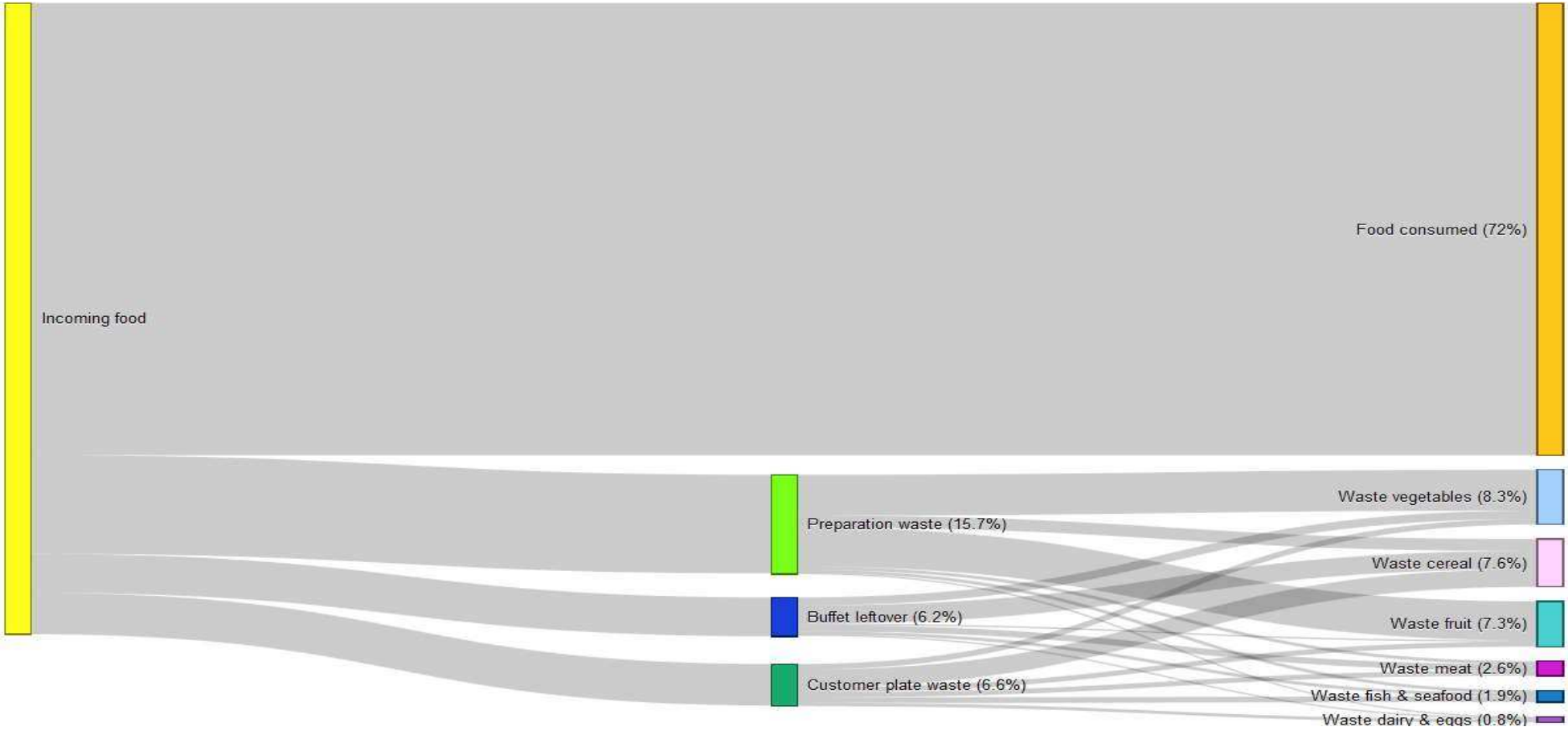
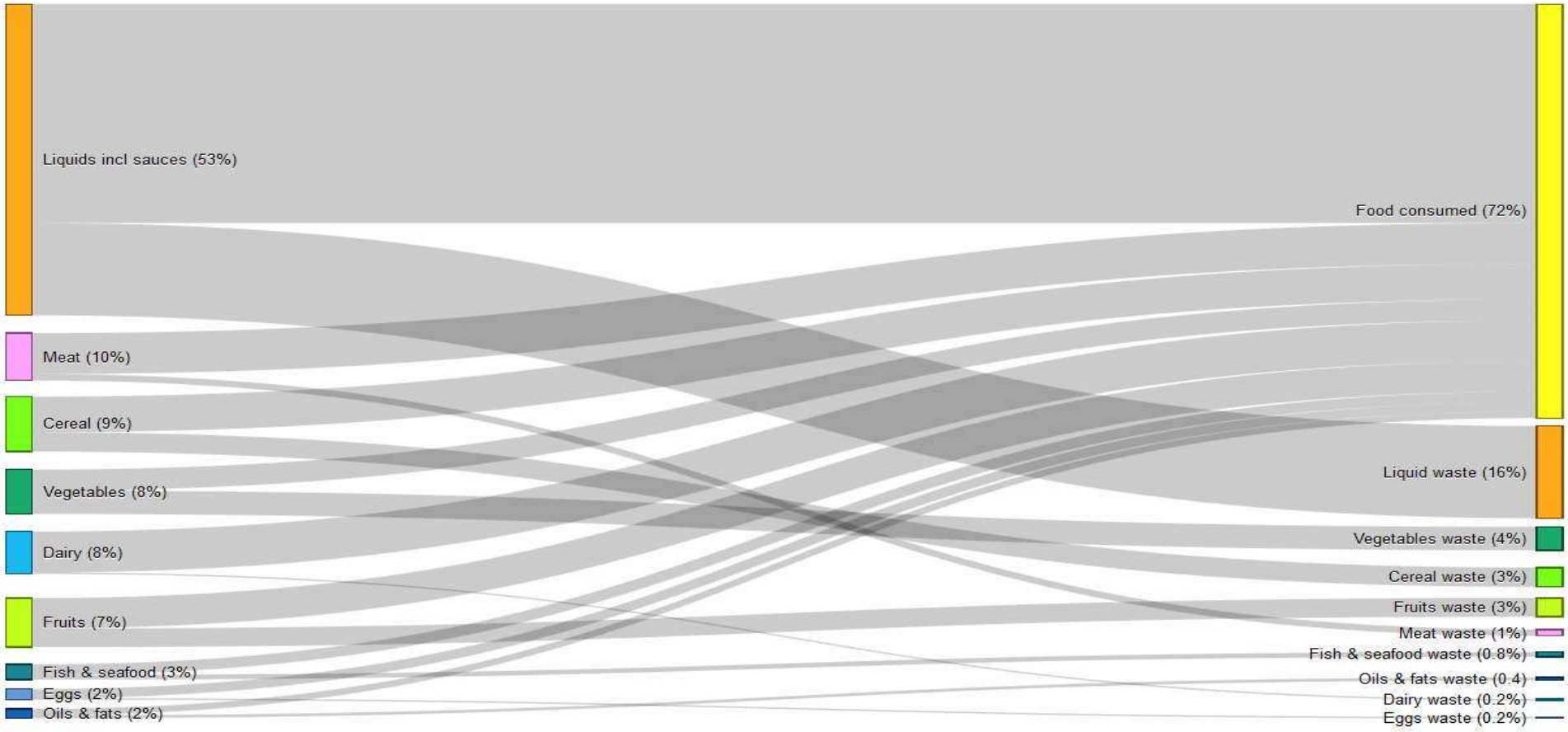


Figure 3: Material flows. Using the software by Bostok (2014)



431

432 Figure 4: Material flows in terms of food commodities. Using the software by Bostok (2014)

433

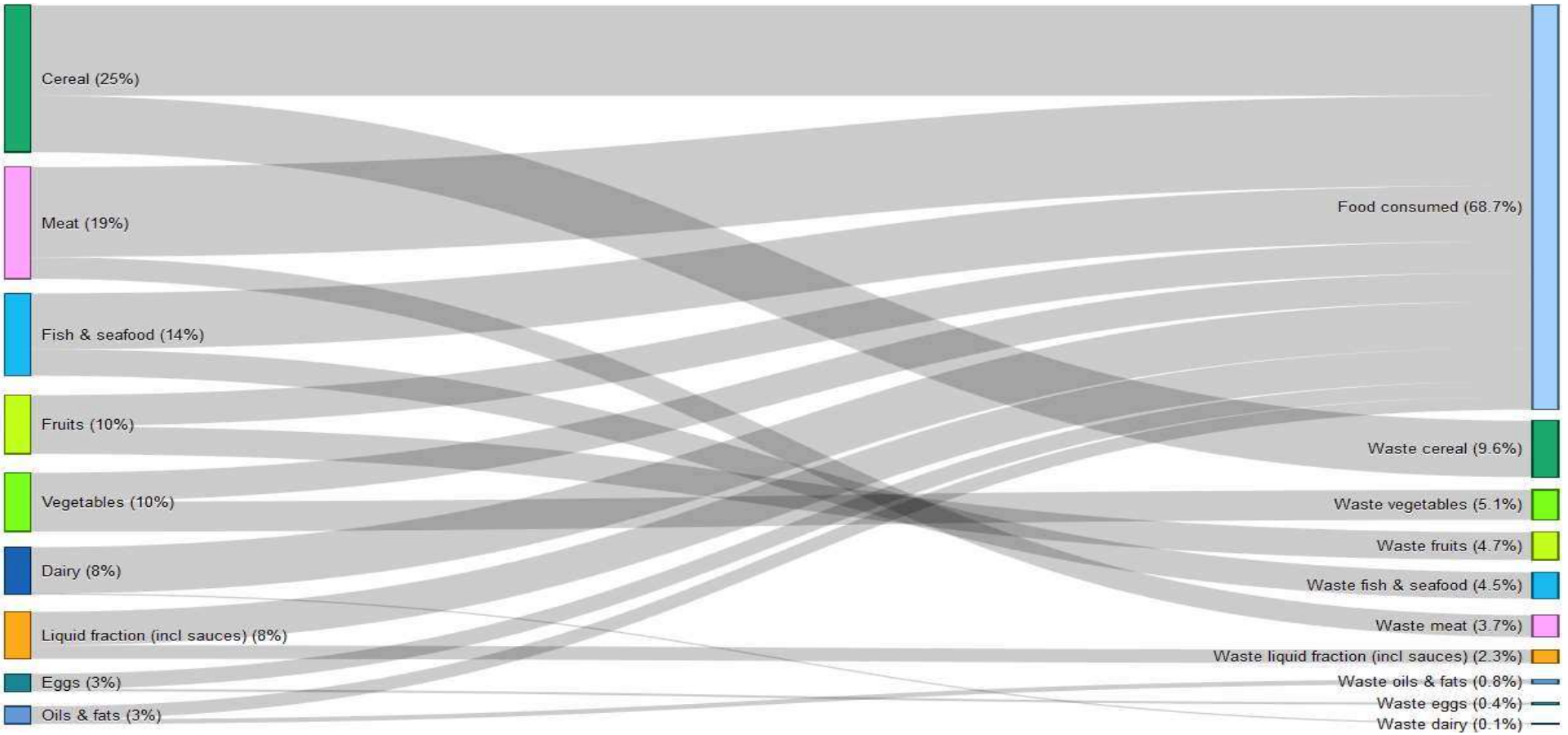


Figure 5: Economic flows. Using the software by Bostok (2014)

The eco-efficiency analysis of the food commodities is presented in Figure 6. 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-efficiency[2] 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 6 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).

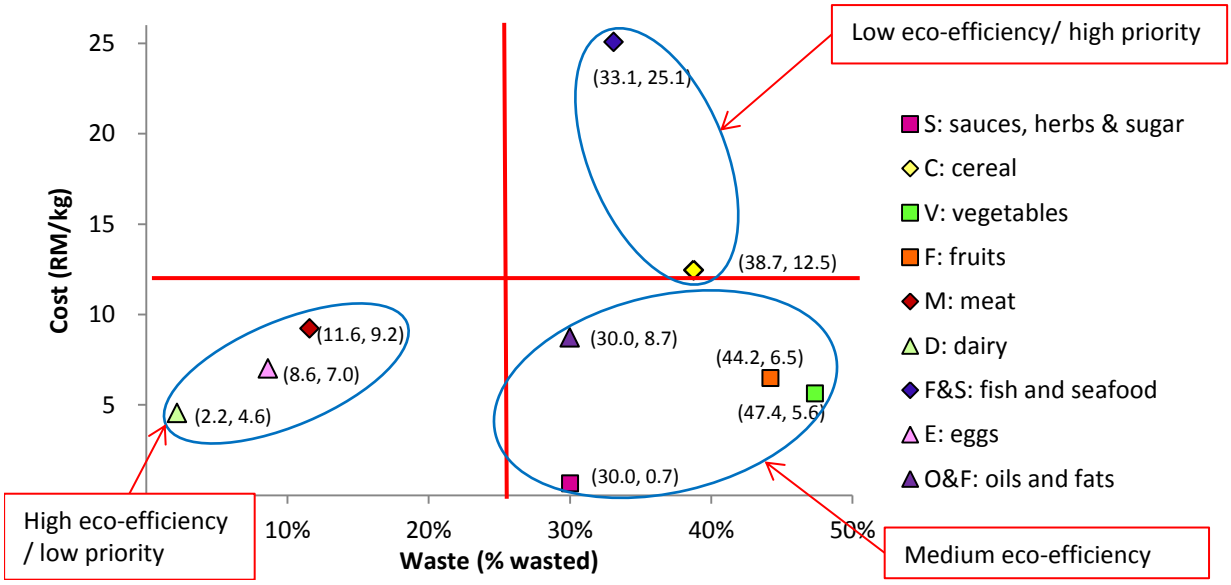


Figure 6: Eco-efficiency of food commodities

4.2 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:

[2] 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.

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 restaurant’s 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. Re-aligning 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.

5 Conclusions

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.

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