

1 **Conceptual framework for the study of food waste generation and prevention in the hospitality** 2 **sector**

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21 **Abstract**

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

41 **Key words:** food waste; hospitality sector; social practices; food provisioning; food consumption;
42 behaviour; material flow; eco-efficiency

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47 **1 Introduction**

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

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

71 The paper is structured as follows. Section 2 presents the background, origins and applications of the
72 tools, methods and research strategies incorporated in the proposed conceptual framework and how
73 the framework was developed. Section 3 explains how these tools, methods and research strategies
74 have been applied within the framework. In Section 4 a case study of food waste generation in a
75 hotel restaurant in Malaysia is used as an example to illustrate how the proposed conceptual
76 framework can be applied in a real research setting. The discussion on how the results from the case
77 study relate to the literature on food waste generation is also presented in Section 4. Finally, the
78 conclusions and the implications of the paper are presented in Section 5.

79 **2 Literature review**

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

87 The first quantitative method discussed in this section is the waste audit. Waste audits are used in
88 baseline studies to assess hotspots of food waste generation and inform waste prevention and
89 management strategies (WRAP, 2011). They measure the quantity and composition of waste streams

90 with the use of weighing scales and in-situ compositional analyses. Often waste audits are carried out
91 for small samples that represent a larger population since they are time and labour intensive. They
92 are often repeated at different times to account for seasonal or other time related variations. In
93 research, waste audits are mainly applied in descriptive, baseline waste characterisation studies
94 (Okazaki et al., 2008; Wilkie et al., 2015).

95 Waste studies rely heavily on quantitative data (Newenhouse and Schmit, 2000), which can be
96 analysed with the use of tools and methods from the field of industrial ecology, such as Material
97 Flow Analysis (MFA) and eco-efficiency analysis. MFA is a systematic assessment of the flows and
98 stocks of materials within a system defined in space and time (Brunner and Rechberger, 2003). MFA
99 connects the sources, the pathways, and the intermediate and final sinks of a material. MFA aims to
100 model a socioeconomic system, identify its ecologically and economically relevant flows of energy,
101 materials and chemical substances (Fischer-Kowalski and Huttler, 1999). MFA is often described using
102 the metaphor that the material fluxes represent the metabolism of the system (metabolism of the
103 anthroposphere (Baccini and Brunner, 1991) and industrial metabolism (Ayres, 1989)). The first
104 applications of MFA were within the fields of economics and engineering, although MFA has been
105 increasingly recognised as a useful decision making tool in resource, environmental and waste
106 management (Deutz and Ioppolo, 2015; Rieckhof et al., 2014). MFA has been used in recent studies
107 to quantify food losses in Switzerland (Beretta et al., 2013) and investigate food waste in the Swiss
108 food service sector (Betz et al., 2015). Sankey diagrams can help to illustrate the MFA (Schmidt,
109 2008). A Sankey diagram is a graphic illustration of flows, like energy, material or money flows. The
110 flows are depicted as arrows with the width of the arrows proportional to the size of the flow.

111 In addition to MFA, eco-efficiency is another concept from industrial ecology used in environmental
112 and sustainability research (Gabriel and Braune, 2005). According to the World Business Council for
113 Sustainable Development (WBCSD, 2000) eco-efficiency is concerned with creating more value with
114 less impact. Eco-efficiency as an instrument for sustainability analysis, indicates an empirical relation
115 in economic activities between environmental cost or value and environmental impact (Huppel and
116 Ishikawa, 2005). Eco-efficiency can be expressed by the ratio of economic value/environmental
117 impact (WBCSD, 2000). Eco-efficiency is improved by reducing the environmental impact while
118 maintaining or increasing the economic value. Although the concept of eco-efficiency has been
119 applied predominately at a product level, as a tool it has been used for example to promote the
120 competitiveness of economic activities in a Finnish region and mitigate their harmful environmental
121 impacts (Seppälä et al., 2005) and to evaluate waste management options in China (Zhao et al.,
122 2011). In the waste management field it has been a useful tool in comparing competing waste
123 management options (Pires et al., 2011).

124 Despite their strengths, eco-efficiency analysis and MFA do not allow for the analysis of social
125 practices, motivations and behaviours of waste producers. A number of methods can be used to
126 analyse such phenomena, such as ethnography and Grounded Theory (GT).

127 Ethnography is the systematic study of people and cultures, rooted in the social sciences used
128 extensively in anthropology and sociology (Gobo, 2008a). Such studies are conducted on a system
129 bounded in space and time and embedded in a particular physical and sociocultural context
130 (Emerson et al., 2001). In ethnography, the researcher spends a considerable amount of time
131 carrying out field work in order to participate in the social life of the actors observed, while at the
132 same time maintaining sufficient cognitive distance so that he or she can remain objective (Emerson
133 et al., 2001). Various data collection methods are available in ethnography, including participant

134 observations, interviews, focus groups, audio-visual material and documents (Gobo, 2008b). A
135 number of waste and food waste studies have used an ethnographic approach (Evans, 2014, 2011;
136 Goonan et al., 2014; Gregson et al., 2013; Hetherington, 2004). In these studies a mixture of data
137 collection methods were used such as interviews, focus groups and participant observation.

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

159 In GT, the researcher uses multiple stages of collecting, refining, and categorizing the data (Charmaz,
160 2014). The principles of emergence, theoretical sampling, and constant comparison are fundamental
161 in GT in order to obtain a theory grounded in the data (Corbin and Strauss, 2008; Walsh et al., 2015).
162 The principle of emergence requires that the researcher approaches the subject of research with as
163 few predetermined ideas as possible and remains open to what is discovered empirically. This is
164 achieved through the processes of theoretical sampling and constant comparison (Glaser and
165 Strauss, 1967). Theoretical sampling is the process in which the researcher simultaneously collects,
166 codes, and analyses data, with the purpose of generating and developing theoretical ideas. In this
167 process the researcher makes decisions about the type of data worthwhile collecting and analysing in
168 order to develop aspects of the emerging theory (Glaser, 1978). Through the constant comparative
169 method data are continuously compared with previously collected and analysed data as the
170 researcher determines if the new data support (or not) the emerging concepts. GT has been used
171 mainly in sociology, nursing, management, education, marketing and the information systems field
172 (Bryant and Charmaz, 2007). In the waste management field Gai et al. (2009) used GT to analyse data
173 from interviews about medical waste management in China. The coding procedures of GT were used
174 in a number of studies to understand the drivers for householders to minimise waste (Graham-Rowe
175 et al., 2014) and commuters' motivation to use a car (Gardner and Abraham, 2007). In most of these
176 cases GT was used as a method of analysis of qualitative data, not with the intention of deriving new
177 theories.

178 2.1 Definitions of food waste

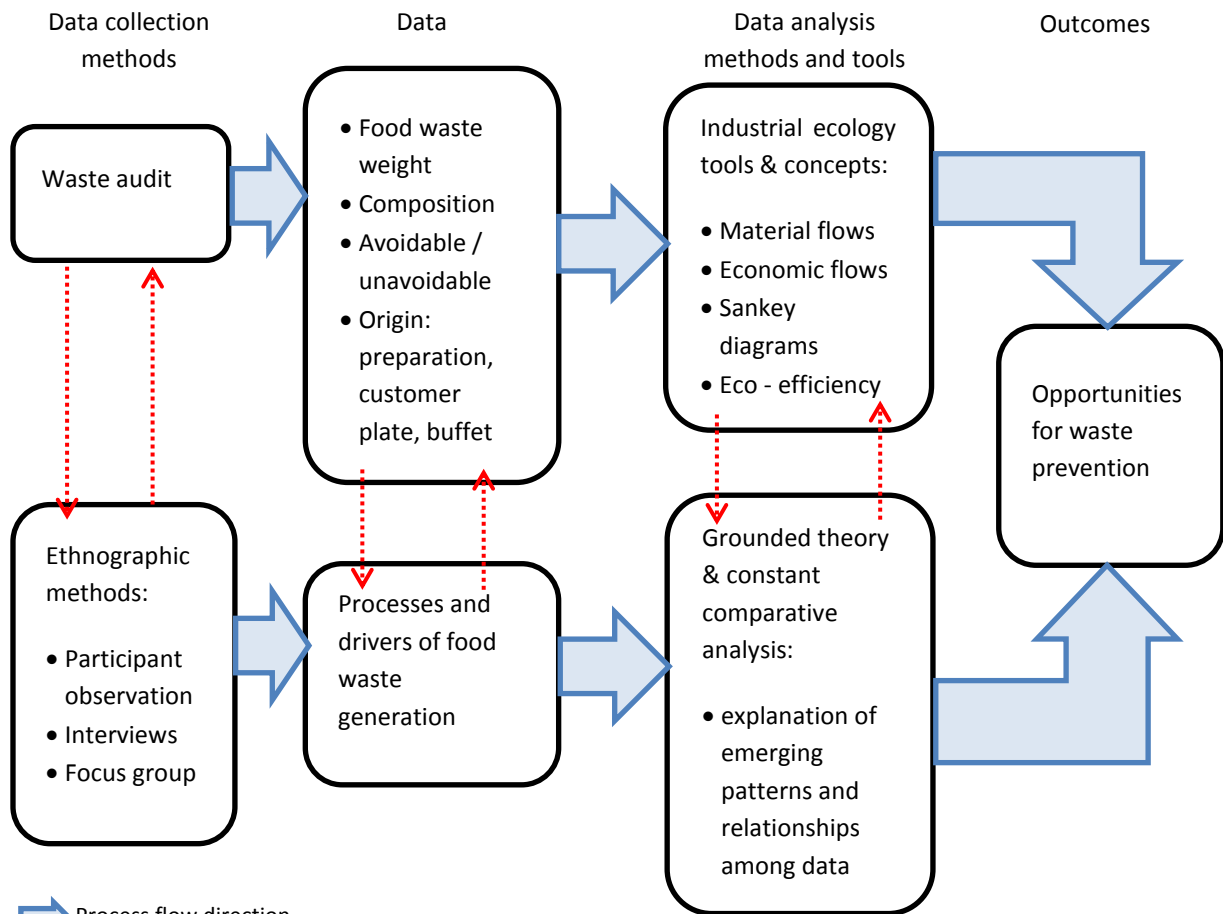
179 The FAO defines food waste as food which was originally produced for human consumption but was
180 not consumed by humans, instead it was directed into a non-food use (for humans), feed for animals
181 or waste disposal (e.g. feedstock to an anaerobic digestion plant or incinerator, disposal at a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

192 2.2 Developing a conceptual framework for the study of food waste generation and prevention

193 The conceptual framework for the study of food waste generation and prevention presented in this
194 paper was developed from the literature (based on Betz et al., 2015; Evans, 2011; Evans et al., 2013;
195 Graham-Rowe et al., 2014; Quested et al., 2011) (

196 Figure 1). It was designed so it can respond to the challenges faced in the research process and adapt
197 to the individual nature of a particular case study. In the initial stages of the development of the
198 conceptual framework, a waste audit featured as the main tool for data collection, focusing primarily
199 on quantitative data such as weight, composition and origin of food waste; however, the waste audit
200 offered limited insights into the drivers for food waste generation. Building from ethnography,
201 methods such as participant observation, interviews and focus groups were incorporated in order to
202 collect qualitative data. The framework is designed in such a way that both quantitative and
203 qualitative methods are carried out simultaneously and the emerging findings inform the direction
204 and focus of both methods. For example, a preliminary analysis of the waste audit data can indicate
205 which stages of the food preparation and consumption the qualitative methods should focus more
206 on, and what questions would yield deeper insights during the interviews and focus group. In a
207 similar way, insights on the drivers of food waste generation arising from the qualitative methods can
208 inform the type of quantitative data needed to prove or disprove the main points coming out of the
209 interviews. This exchange of findings and results between the different methods, illustrated by the
210 use of dotted red arrows in Figure 1, is designed to happen concurrently to the actual data collection
211 and analysis process.

212 Figure 1 suggests a linear process flow; in reality the research process involved a number of cycles of
213 simultaneous data collection and analysis, before reaching a conclusion.



214 Process flow direction
 215 Exchange of findings between quantitative & qualitative methods

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

218 **3 Methods**

219 The conceptual framework for the study of food waste generation and prevention was implemented
 220 and tested in a case study. The unit of analysis for the case study was a hotel restaurant. The case
 221 study used in-depth and semi-structured interviews, focus groups, observation, and quantitative data
 222 collection techniques. Food waste generation was studied from the time of purchasing of raw food
 223 supplies, throughout food storage, preparation and cooking, consumption and, finally, discarding of
 224 food waste. An in-depth analysis of waste collection and final disposal was not included, since these
 225 stages are outside the remit and control of the restaurant.

226 **3.1 Quantitative methods and tools from industrial ecology**

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

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

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

251 These three types of food waste were recorded and linked to a specific type of meal (breakfast,
 252 lunch, or dinner). This allowed conclusions to be drawn about the most wasteful eating times and the
 253 food types that contributed most to the wastage. Significant efforts were made into capturing food
 254 waste at the point of generation and recording not only its total weight but also the weight of its
 255 individual ingredients before they were mixed with the rest of the food waste; however, in the case
 256 of oils a combination of weighing and estimation based on visual observations was used because it
 257 was not always possible to separate the oil from the cooked meals. This approach provided sufficient
 258 information in order to categorise food and food waste into nine food commodity groups, including
 259 oils, and produce detailed material flow diagrams. The food commodity categories are presented in
 260 Table 1.

261 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, 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

262 Adapted from (Gustavsson et al., 2011)

263 The weight and composition of the food waste was then combined with the incoming flows of food
 264 to produce economic flows graphs and eco-efficiency ratios for each food commodity group. The
 265 incoming flows of the fresh food delivered and cooked daily, such as fruits, vegetables, meat, fish,

266 were determined by the food purchasing and delivery records of the waste audit week. For food
267 items used from the stock, such as oils, rice, pasta, canned foods, the average weight used in a week
268 was extrapolated by the food purchasing inventory records of the previous 12 months. Using two
269 different ways to calculate the weight of incoming food and outgoing waste is a limitation of the
270 method. In order to overcome this limitation, the extrapolated figures were verified by the chefs as
271 an accurate reflection of the amount used within a week.

272 The material and economic flows were illustrated with the use of Sankey flow diagrams. Sankey flow
273 diagrams were used to visualise the magnitude of economic and material flows taking place within
274 the case study. The thickness of each link in the diagrams represented the amount of flow from a
275 source to a target node, in this occasion from food provisioning to food consumption. In order to
276 calculate the eco-efficiency of the different food commodities, the cost parameter was matched with
277 the environmental parameter, in this case waste generation (WBCSD, 2000). The cost parameter was
278 expressed in Ringgit Malaysia¹ (RM)/kg of food, and the environmental parameter as percentage of
279 food wasted. The eco-efficiency ratios were plotted in a graph with the y axis representing the food
280 cost and the x axis the percentage of food wasted. The graph was then divided into four quarters
281 representing high, medium and low eco-efficiencies. For example, a food item of high cost and high
282 waste would be plotted on the top right quarter of the graph and have a low eco-efficiency, whereas
283 a food item of low cost and low waste would be plotted at the bottom left quarter and have a high
284 eco-efficiency. The classification of high, medium or low eco-efficiency was done comparatively to
285 other food items, instead of absolute terms.

286 3.2 Ethnographic and qualitative methods: interviews, participant observation and focus groups

287 Two types of interviews were carried out in this study: in-depth structured and informal non-
288 structured. In-depth interviews of sixteen employees from the case study restaurant and three
289 representatives of the National Solid Waste Management Department were carried out in order to
290 understand the broader context in which food waste generation occurred in the hospitality sector.
291 Following the initial round of in-depth interviews, participant observation combined with informal
292 non-structured interviews with the restaurant employees were carried out while collecting
293 quantitative data. The observations were recorded through field notes in the form of a diary (Evans,
294 2011).

295 A focus group was also carried out following some preliminary data analysis. The main patterns
296 emerging from the data were discussed in the focus group comprising seven members of the
297 management, procurement, sales, finance, food preparation and operations teams of the restaurant.
298 The focus group was conducted in English, since it is the common language used among the
299 restaurant staff of various nationalities. The focus group allowed further analysis and verification of
300 the data collected through the other methods and opportunity to seek clarification on behaviour
301 recorded during the participant observation. It offered further insights as to where, how, why food
302 waste was produced, and what could be done to prevent it.

303 3.3 Grounded theory and the constant comparative analysis method

304 The conceptual framework for studying food waste generation and prevention was based on an
305 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)

306 constant comparative analysis method from grounded theory was applied by continually comparing
 307 sections of the data, to allow categories to emerge and for relationships between these categories to
 308 become apparent (Glaser and Strauss, 1967). The emerging categories were then modified into more
 309 abstract concepts. Theory was built by organising these concepts into logical frames. As new data
 310 emerged, new concepts were added until a point of 'saturation' was reached whereby new data no
 311 longer contributed anything new. The theory that was developed through this process explained
 312 how, why and where food waste was produced and finally helped to identify the most promising
 313 measures for food waste prevention.

314 **4 Results and discussion**

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

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

333 4.1 Food waste generation patterns and drivers

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

337 Table 2: Daily food waste generation in a week

	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Daily	Stand.
	02/05/14	03/05/14	04/05/14	05/05/14	06/05/14	07/05/14	08/05/14	averagedeviation	
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

338

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

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

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

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

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

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

367 The average food waste generation per customer served is shown in Table 3. These figures can serve
 368 as a benchmark for food waste generation, regardless whether many or only a few customers were
 369 served at a particular time. The results suggested that the lunch time ‘a la carte’ meal had the highest
 370 food waste generation rate; however, this figure was based only on one meal time (Sunday
 371 4/5/2014) which was a particularly wasteful occasion (see paragraph above). The breakfast buffet
 372 had the second highest food waste generation rate at 1.2 kg per customer served, followed by the

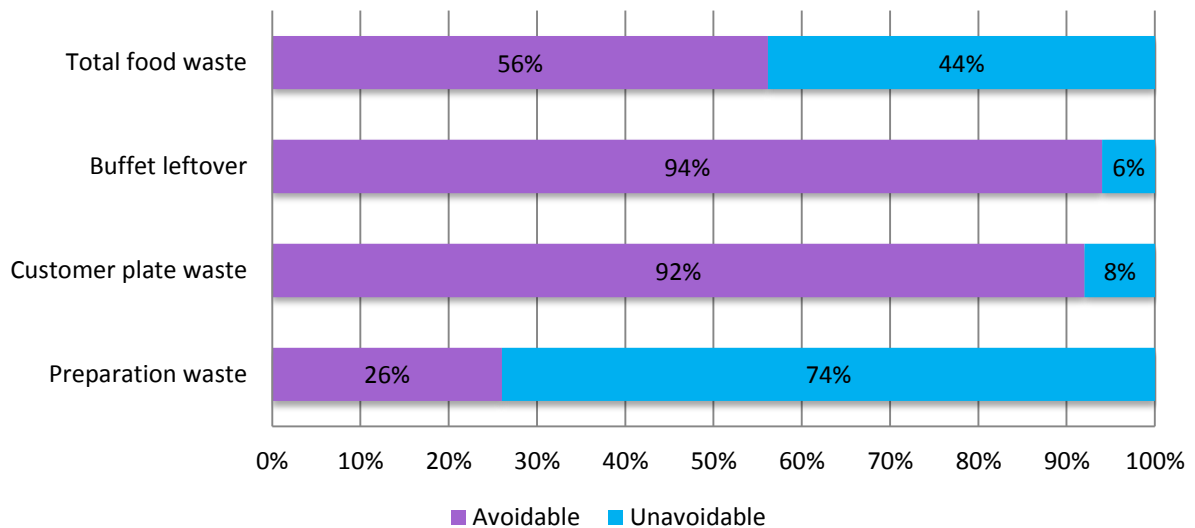
373 lunch time buffet with 1.1kg per customer and dinner time buffet and 'a la carte' service, with 1kg
 374 per customer. If the outlier of the lunch time 'a la carte' meal was excluded, the figures suggested
 375 that buffet style service was overall more wasteful than 'a la carte' service. Buffet service had lower
 376 preparation waste per customer rates, as explained by economies of scale; however, it produced
 377 substantial amounts of buffet leftover, making it a more wasteful type of service.

378 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

379
 380 The patterns from the data in tables 2 and 3 and the subsequent observations of food preparation
 381 and consumption demonstrate how food waste generation was affected by the type of service
 382 provided (for example 'a la carte' as opposed to buffet) and food consumption practices of the
 383 customer (as influenced by values and cultural beliefs). Food waste from buffet operations was highly
 384 dependent on the types of individual events and functions taking place every day, causing daily
 385 variations in the amount of food waste. In addition to the type of service provided, the nature of the
 386 restaurant was such that the majority of the food was cooked from scratch, using fresh ingredients
 387 and very few processed items. This lead to having all the preparation waste associated with a certain
 388 meal, produced within the restaurant and not in previous stages of the food supply chain, e.g. food
 389 processing industries.

390 Another important feature of food waste generation was the percentages of avoidable and
 391 unavoidable fractions of food waste. As Figure 2 illustrates, 56% of all food waste generated in this
 392 case study was avoidable, which shows the significant scope for food waste prevention. At the
 393 preparation stage, the majority of food waste was unavoidable as it comprised of mainly inedible
 394 parts of foods, such as bones, seafood shells, inedible fruit skins and cores etc. Buffet leftover was
 395 mainly edible, with an avoidable fraction of 94%. Food waste from the customer's plate was a mix of
 396 inedible parts such as bones, seafood shells etc., and edible surplus food. The unavoidable fraction
 397 measured in this case study (44% of total food waste) was significantly higher than the one Betz et al
 398 (2015) report (maximum 21% unavoidable fraction). This was due to the nature of the restaurant in
 399 this case study: high quality food prepared from scratch resulting in high preparation waste
 400 consisting of inedible parts such as bones and exotic fruit skins for example. The second reason was
 401 that, in this study, the possibly avoidable food waste fraction was reported within the unavoidable
 402 fraction. These type of variations, due to the subjective nature of definitions of avoidable and
 403 unavoidable fractions, as well as due to the extent which the restaurant used pre-prepared food,
 404 were acknowledged by Betz et al as well (2013).

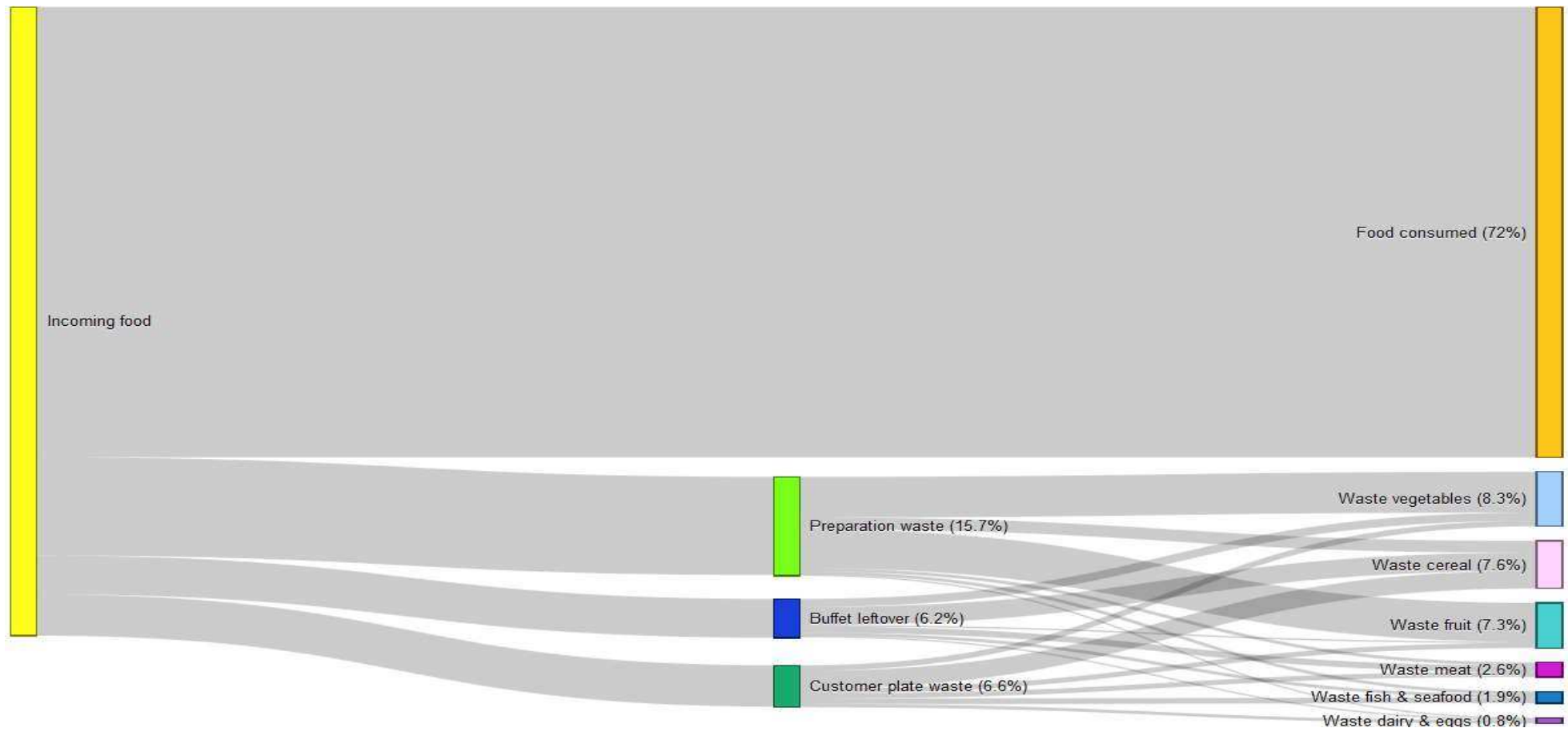


405

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).

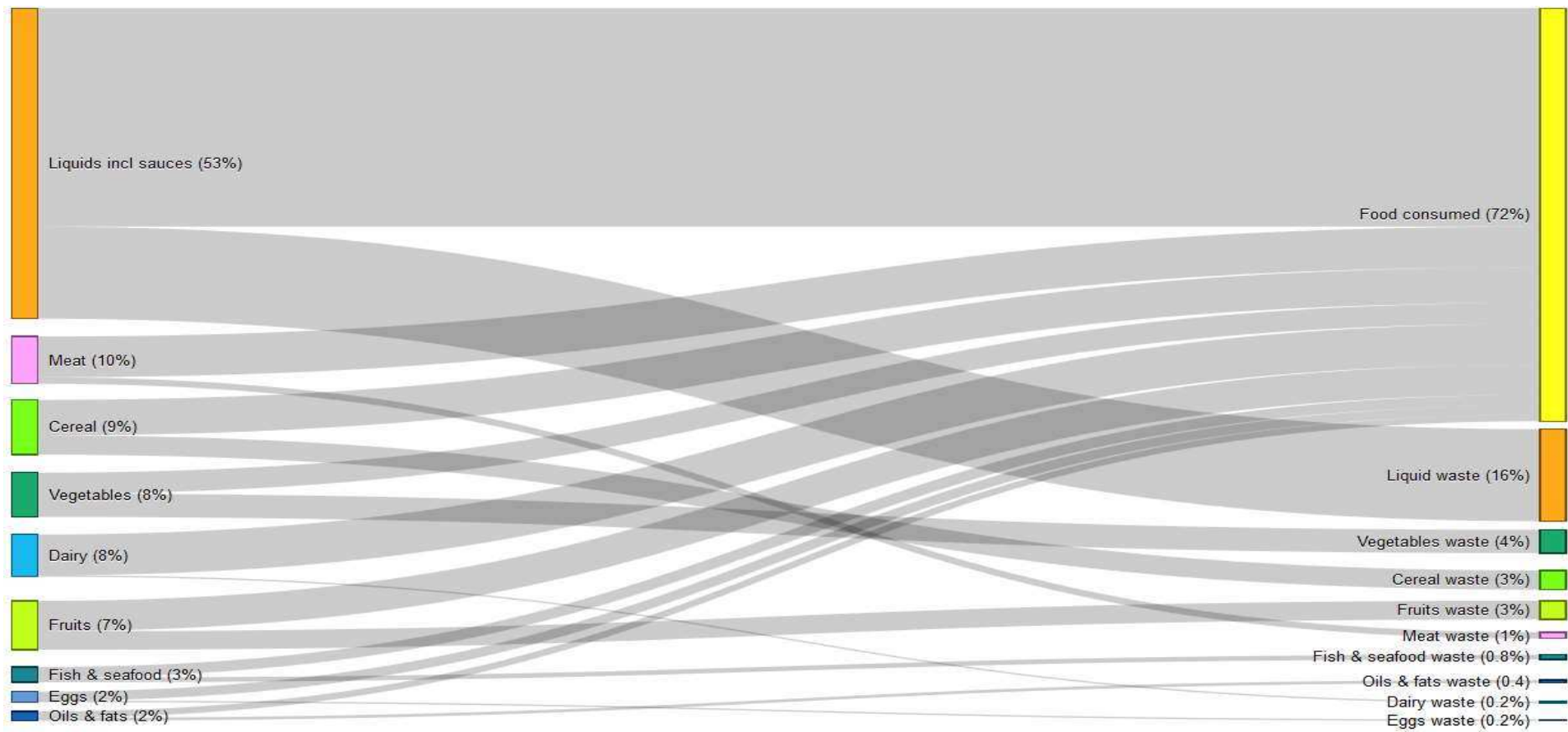
423 Figure 5 shows the economic flows that took place within the restaurant, broken down in the nine
 424 food commodity groups. This graph provides a different perspective to the previous graphs. It shows
 425 that although the liquid fraction was the most significant waste component in terms of weight (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.



428

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

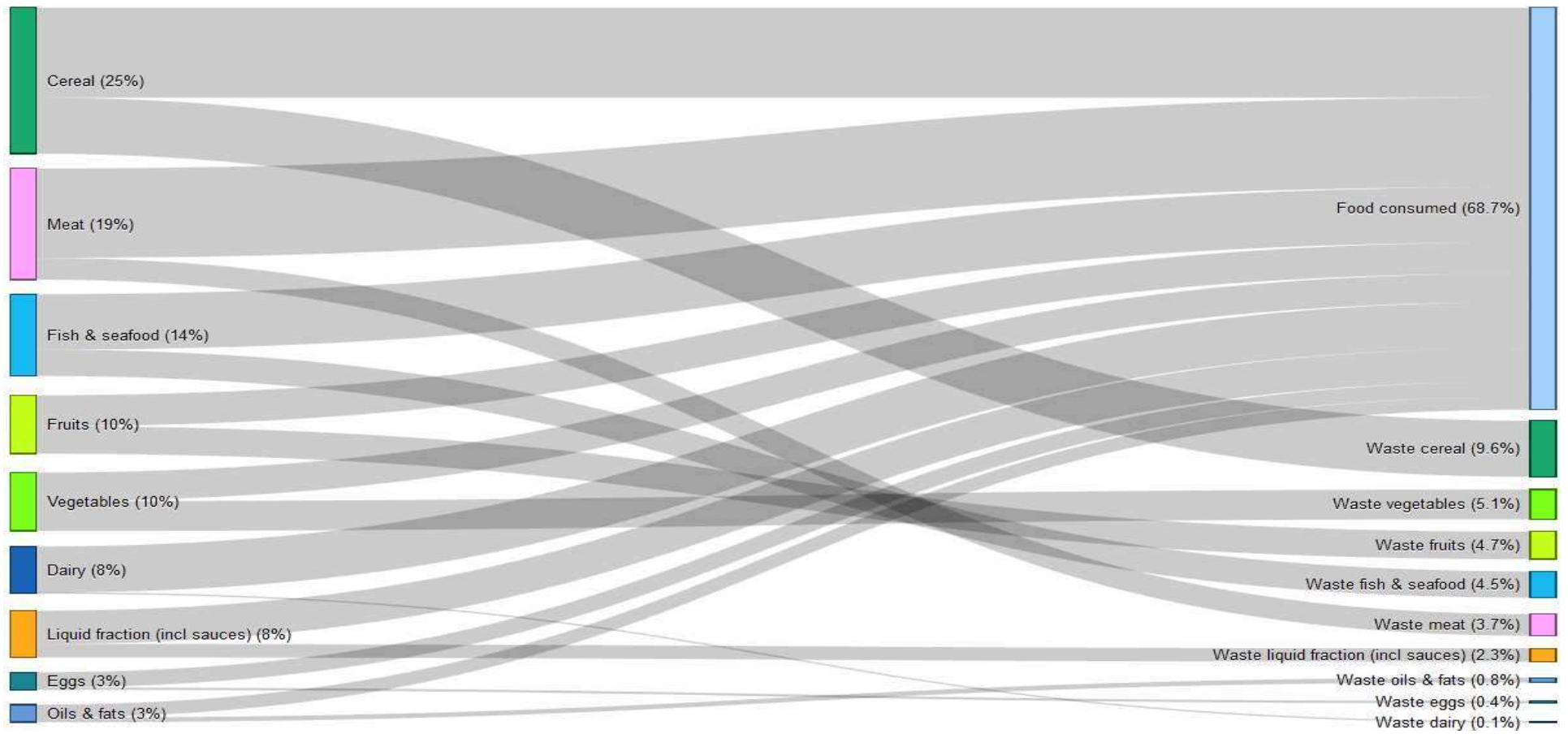
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432 Figure 4: Material flows in terms of food commodities. Using the software by Bostok (2014)

433



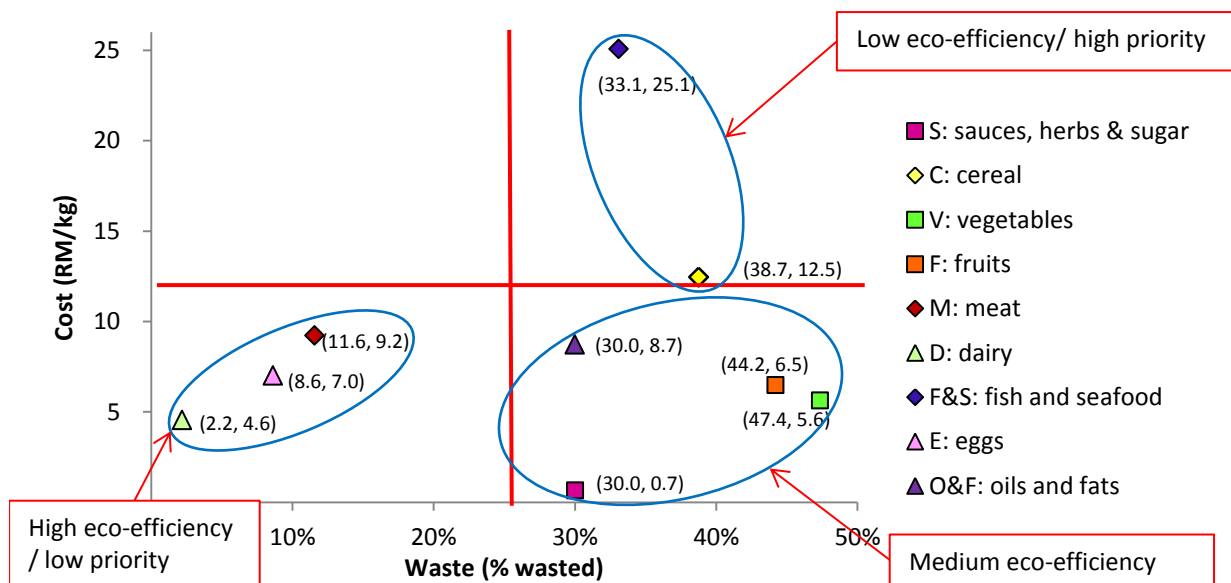
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435

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

436

437 The eco-efficiency analysis of the food commodities is presented in Figure 6. Cereal, fish and seafood
 438 appear at the top right quarter of the graph, representing food commodities that are both costly and
 439 generate high amounts of waste, hence have a lower eco-efficiency² than the other food
 440 commodities. Fruits, vegetables, sauces, oils and fats are relatively less costly even though they
 441 generated higher amount of waste, and could be classified as having a medium eco-efficiency
 442 comparatively to the other food items. Meat, dairy, eggs, generated the least waste and were less
 443 costly when compared to the high cost foods such as fish and seafood, giving them a higher eco-
 444 efficiency rating. Figure 6 could help the restaurant focus and prioritise its food prevention strategy,
 445 starting with low eco-efficiency items (high cost – high waste group), followed by the medium eco-
 446 efficiency items (low cost – high waste group), and finally the high eco-efficiency items (low cost –
 447 low waste group).



448

449 Figure 6: Eco-efficiency of food commodities

450 4.2 Food provisioning and restaurant operations as drivers of food waste generation

451 Observations of the general procedures and practices outside the kitchen revealed a number of
 452 broader factors effecting food waste generation. These factors had to do with the way the restaurant
 453 operated and provisioned food. For example, in buffet operations food was prepared in advance. The
 454 quantity of food to be prepared was based on the reservations made and estimates of additional
 455 customers turning up on the day without any reservation. Accurate prediction of the number of
 456 customers to prepare food for was crucial in avoiding food surplus. In other words, if food was
 457 prepared for the actual number of customers being served, then food waste could be minimised. In
 458 order to achieve this, pre-booking was essential. This driver for food waste generation became
 459 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.

460 Researcher: "Why do you think the buffet is more wasteful than the 'a la carte'?"

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

466 Researcher: "But then you end up wasting a lot of food"

467 Chef: "Well yes, but it's better to waste food than lose the customer right?"

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

473 Another driver for food waste generation related to the restaurant's operation was uncovered
474 through participant observation and was later confirmed in interviews with the restaurant's
475 manager. This driver related to the strict policy on the maximum time duration food can be left on
476 the buffet. The policy specified that food items should not be left on the buffet for periods longer
477 than four hours. For example, if a dish was served during the breakfast buffet and it was not
478 consumed, it could not be served again during lunch time and had to be discarded. Although the
479 policy aimed to ensure the food served was fresh and safe for the customer's benefit, it led to
480 significant quantities of buffet leftover waste.

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

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

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

496 Purchasing staff: "We take the orders from the kitchen on what they need a week before. We need
497 to keep costs down, so we can't make last minute changes to the order because then we won't get
498 the best price for the produce. We buy a bit more than what we need, you know especially for things
499 that keep longer, but if the booking changes then the kitchen has to deal with it."

500 Sales staff: “We know this causes problems in the kitchen, but we can’t turn down the customer
501 request. We need repeat business and if we start telling them they can’t change the booking then
502 they’ll not come back”

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

507 The case study revealed the significant potential for food waste prevention in this particular
508 restaurant, considering the high avoidable waste percentage (56%). A key recommendation for
509 preventing food waste is offering ‘a la carte’ rather than buffet style service; however, when buffet
510 style service is offered operating at full capacity can maximize the benefits of economies of scale, and
511 actively encouraging more accurate prediction of customer numbers rather than relying on preparing
512 30% surplus food could make the buffet less wasteful. Additional food waste prevention strategies
513 include targeting the commonly wasted items such as fruits and vegetables by improving food
514 preparation techniques, as well as the most commonly wasted dishes such as rice, noodles, cakes
515 and desserts, by reducing portion sizes. Increasing the eco-efficiency of fish, seafood and cereals
516 should also be a priority. Revisiting the blanket buffet food safety policy in order to allow chefs to
517 decide on a case by case basis how long dishes should remain on the buffet has the potential for
518 further food waste reductions. Re-aligning targets of the different departments in the restaurant and
519 connecting them back into the company’s central values could result in better communication and
520 coordination between the departments, which in turn has the potential for further food waste
521 reduction.

522 **5 Conclusions**

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

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

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

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