

To my beloved family who made my dream come true with their support and belief.



UNTANGLING THE COMPLEX NATURE OF HOUSEHOLD FOOD WASTE
DRIVERS THROUGH FUZZY COGNITIVE MAPPING

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August, 2021

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ABSTRACT

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Since reducing household food waste (HFW) has serious environmental, social, and economic implications, researchers across disciplines have investigated this phenomenon from multiple angles and identified a substantial number of drivers that account for HFW. Despite these efforts, empirical investigation of the complex web of HFW drivers is still in its infancy. The methodologies that have been used to investigate the phenomenon have been generally insufficient in capturing the complexity surrounding consumers' food waste behavior. Therefore, the main objective of this thesis is to provide a more complete representation of this complexity. To this end, a distinctive method, fuzzy cognitive mapping (FCM) was used to demonstrate the system of HFW drivers. Through an iterative process between the content analysis of previous studies and expert opinion, the most prevalent HFW drivers as system concepts and their causal relationships were synthesized and consolidated in the first stage. Then in the second stage, this well-refined framework was transformed into an FCM that provides a consistent base to conduct simulations and to compare the HFW-reducing intervention alternatives. In the third stage, the most influential drivers were revealed, and the ambiguities due to conflicting findings reported in the literature were resolved. Then, through scenario analysis, intervention alternatives were compared based on their impact on HFW. In the final section,

findings of each stage were integrated and discussed with their theoretical, methodological, and practical implications.

Keywords: Household food waste, social practice theory, fuzzy cognitive maps, complexity, scenario analysis



ÖZET

HANEİÇİ GIDA İSRAFINI ETKİLEYEN FAKTÖRLERİN KARMAŞIK YAPISININ BULANIK BİLİŞSEL HARİTALAMA YOLUYLA ELE ALINMASI

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Haneîçi gıda israfının (HGİ) azaltılması önemli çevresel, sosyal ve ekonomik sonuçlar doğuracağından, farklı disiplinlerden araştırmacılar bu olguyu çeşitli yönleriyle araştırmış ve HGİ'ye neden olan çok sayıda faktör belirlemişlerdir. Buna rağmen, HGİ ile ilgili faktörlerin karmaşık ağının ampirik araştırması hâlâ emekleme aşamasındadır. Bu olguyu araştırmak için kullanılan yöntemler, tüketicilerin gıda israfı davranışını çevreleyen karmaşıklığı yakalamada genellikle yetersiz kalmıştır. Bu nedenle, bu tezin temel amacı, bu karmaşıklığın daha bütün bir gösterimini sağlamaktır. Bu amaçla, HGİ ile ilgili faktörlerin oluşturduğu sistemi göstermek için farklı bir yöntem olan bulanık bilişsel haritalama (BBH) kullanılmıştır. İlk aşamada, daha önceki çalışmaların içerik analizinin yapılması ve konu ile ilgili uzman görüşü alınması şeklinde ifade edilebilecek iki adım arasında tekrarlanan bir süreç takip edilmiştir. Bu süreç sonucunda sistem kavramları olarak tanımlanan en yaygın HGİ'ye neden olan faktörler ve bu faktörlerin arasındaki nedensel ilişkiler belirlenmiş ve birleştirilmiştir. İkinci aşamada, bu iyi tanımlanmış çerçeve, simülasyonları yürütmek ve HGİ'yi azaltmaya yönelik olarak tasarlanan müdahale alternatiflerini karşılaştırmak için tutarlı bir temel sağlayan bir BBH'ye dönüştürülmüştür. Üçüncü aşamada, en etkili faktörler ortaya çıkarılmış ve literatürdeki çelişkili bulgulardan kaynaklanan belirsizlikler çözülmüştür. Ardından, senaryo analizi yoluyla, yukarıda

bahsedilen müdahale alternatifleri HGI üzerindeki etkilerine göre karşılaştırılmıştır. Son bölümde ise, her aşamanın bulguları bütünleştirilmiş ve teorik, metodolojik ve pratik çıkarımları açısından tartışılmıştır.

Anahtar kelimeler: Haneîçi gıda israfı, sosyal pratik teorisi, bulanık bilişsel haritalar, karmaşıklık, senaryo analizi



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CHAPTER 1: INTRODUCTION

1.1 Importance of Household Food Waste Phenomenon

On the one hand, more food must be produced to feed the growing world population which is expected to reach 9 billion people by 2050 (Gobel et al., 2015) one-third of all food produced in the world is wasted (FAO, 2011). The global demand for food, estimated to be continuing for at least 40 years, leads to the overutilization of land, water, and energy. These issues revive the notion of a sustainable food system to increase food availability as well as to minimize environmental, economic, and social impacts (Thyberg & Tonjes, 2016). Therefore, food waste reduction has become an essential target to achieve a sustainable food system (Gobel et al., 2015). The twelfth item of seventeen sustainable development goals set by the United Nations, for instance, aims to ensure sustainable consumption and production patterns, and one of the identified targets to reach that lofty goal is halving per capita global FW at the retail and consumption levels (UN, n.d.).

Throughout the food supply chain – the combination of stages through which food is transported, processed, packed, stored, sold, and consumed (Gustavsson et. al., 2011) – edible food mass decreases at each stage. Among the players involved in the food journey, households, particularly in developed regions, are regarded as the main contributor to the total amount of FW generated (Bravi et al., 2020). In Europe, households are responsible for more than half of the total food waste (WRAP, 2013). In some countries, this ratio is even more drastic (e.g. 70% in the UK).

In addition, consumers' preferences, expectations, and demands influence the whole chain backward and cause food loss even in the initial stages (Göbel et. al., 2015). Therefore, the exploration of why human beings waste food has become a central focus in the food waste reduction efforts.

1.2 Why People Waste Food in Households?

For the exploration of why people waste food in households, social practice theory offers the most appropriate framework in the literature. According to theory, practices – an organized nexus of activities that is routinely reproduced – such as the way of consuming or cooking engrave social life. The basic tenant of this theory is that traditions and standards of practice orient the behavior rather than personal choices and tastes. Therefore, the analysis of social life should take practices as the unit of analysis, not the individuals. Since practices are formed through the gift structure of interconnected several elements – such as rules, beliefs, emotions, materials, meanings, forms of competence, and so on – the examination of how these key elements are seized and accommodated the performance of practice is key to understand behaviors including FW behavior.

Applying to the social practice theory (Schatzki, 1996, Warde, 2005), many scholars (Aschemann-Witzel et al., 2015; Dobernig & Schanes, 2019; Evans, 2011; Hebrok & Heidenstrom, 2019; Porpino et al., 2015 and others) have identified a wide range of routinized types of behaviors (Reckwitz, 2002) that are stubborn to change (Sahakian and Wilhite, 2014) and cause household food waste (HFW). These were HFW-generating intertwined food-related practices – shopping and meal planning, shopping, storing, preparation and serving, assessing edibility, consumption, leftover managing, redistributing, and disposal (Roodhuyzen et al., 2017; Schanes et al., 2018). To be more specific, poor shopping and meal planning, excessive purchasing (shopping more than needed), stockpiling, cooking too much, shopping less frequently and so on have been discussed as food waste generating practices.

As suggested by the practice theory, the nexus of these food-related practices is formed by the gift structure of essential elements (Reckwitz, 2002; Schatzki, 1996; Shove & Pantzar, 2005) such as attitudes, preferences, concerns, materials,

food/package/retail properties, socio-temporal factors, knowledge, skills, and awareness. More specifically, lack of food appreciation, preference for fresh or variety, food safety and health concern, environmental and economic concerns, unavailability of smaller packages, past bad experiences, decrease in effort devoted for food practices, lack knowledge/skills regarding how to cook with leftovers or how to assess edibility, lack of awareness regarding the waste amount and its large-scale impacts, and so on were reported as antecedents of HFW-generating practices.

In summary, although a substantial number of drivers that account for HFW have been identified in the literature, these findings are fragmented, split, and contextual. In addition, the high complexity of the HFW system inhibits its empirical demonstration through previously employed methods. This thesis aims to handle this shortcoming by investigating the phenomena from a different methodological perspective: fuzzy cognitive maps.

1.3 The problem

The general climate of opinion prevailing in the literature of HFW drivers highlighted the high level of complexity. Complexity fundamentally emanates from a great number of wide-ranging factors that are directly or indirectly affiliated with HFW (Roodhuyzen et al., 2017). Moreover, the multifaceted nature of the causal web formed between factors exacerbated the complexity. Roodhuyzen et al. (2017: p.48) conceptualized consumer food waste as a “*cumulative result of different causal sequences (pathways) of interacting factors*” which means that a factor by following different pathways might lead to different consequences. This view, to some extent, explains the controversial results regarding the impact of a particular factor. The root cause of factors having such controversy might also be its distance from the main action or decision point through which food is wasted (Hebrok & Boks, 2017). In-between shopping planning and disposing of food, for instance, consumers perform many practices through which they can compensate negative consequences of pure planning as well as cannot remunerate strict planning.

The existence of countless pathways having a disparate influence on the outcome requires the investigation of the behavior of all factors together. Therefore,

the cumulative outcome of interacting factors can be observed. This could be achieved through a systematic approach that was proposed as essential for designing effective interventions. Drawing on social practice theory, Sahakian and Wilhite (2014) emphasized i) addressing multiple elements, ii) targeting the most influential factor, and iii) grabbing rebound effects for an intervention to alter entrenched practices. To achieve these three items, the complex system of HFW factors should be demonstrated with a large range of significant factors, all possible relationships between them, and their relative strength. Previous studies, on the other hand, have failed to address this need due to methodological limitations.

Methods used by the growing body of literature examining HFW drivers were either qualitative (e.g. Dobernig & Schanes, 2019; Farr-Wharton et al., 2014; Mattila et al., 2019) (e.g. interview, participant observation, focus group, ethnographic) or quantitative (e.g. Giordano, Alboni, Cicatiello, et al., 2019; van Dooren et al., 2019) (e.g. questionnaire, survey, experiment). Providing an in-depth understanding of interconnected relationships of multifaceted factors, qualitative studies have revealed causal mechanisms. However, they could not quantify, therefore, prioritize the factors and pathways. Quantitative studies have the potential to close this gap by examining the relationships between factors and HFW amount through statistical analysis. However, they are generally incomplete as they have concentrated on a subset of factors (Roodhuyzen et al., 2017). Incompleteness might stem from the abstract nature of factors that creates a challenge in measurement or concerns regarding being parsimonious. In addition, quantitative studies revealed the influence of individual factors rather than their combined effect, therefore, they are far from having a holistic view.

As the causes of HFW are multifarious, wide-ranging solutions to HFW reduction have been proposed whose effectiveness has come under question in the literature (Reynolds et al., 2019; Schanes et al., 2018; Stockli et al., 2018). Solutions addressing household food-related practices and taken under the scope of this study can be classified as informational campaigns, new food provisioning systems, and technological innovations. Even though these solutions were underpinned by grounding arguments, their effectiveness has been underexplored. Reynolds et al. (2019), for example, discussed how costly research investigating the consequence of

an intervention. It requires, a longitudinal approach through which HFW amounts will be tracked regularly, therefore, requires receiving enough funding and building partner collaboration (Reynolds et al., 2019: p. 24).

Roodhuyzen et al. (2017) argued that understanding the multifactorial and complex nature of HFW drivers is a prerequisite for the development of this line of inquiry. Furthermore, Hebrok, and Boks (2017) made a call for finding new ways to test interventions recommended for HFW reduction. Reynolds et al. (2019) added the need for greater integration of theory and previous research findings into the investigation by adopting different methodological techniques. Reynolds et al. postulated:

“would it, for instance, be possible to combine a qualitative account of social practices that generate food waste with quantitative tools that model the effects of different interventions” (2019: p. 15).

From this respect, introducing new approaches that can overcome the challenges faced with existing methods has great importance to decide which intervention should be made widespread.

1.4 Aim of the Thesis

In this context, the primary aim of this thesis is to provide a more complete representation of causal mechanisms behind HFW drivers that would be beneficial for the analysis of HFW-reducing solutions. To this end, a distinctive method, fuzzy cognitive mapping, that allows addressing the reasons behind complexity as well as testing proposed solutions, was selected. Fuzzy cognitive mapping (FCM) was chosen as a tool that can serve the function of combining qualitative accounts with quantitative tools to model the effects of different interventions.

With a more complete representation of the system of HFW drivers in hand, this research aims to explore the answers to the following questions:

- i) What are the most influential ones among the HFW drivers acknowledged in the literature?
- ii) What is the most prevalent impact of the drivers about which controversial results have been reported in the literature?
- iii) What are the most influential ones among the interventions proposed in the literature to reduce HFW?

1.5 Significance of the Research

This research offers significant theoretical, practical, and methodological implications. First, this research contributes to the theory by extracting and integrating fragmented, split, and contextual knowledge of HFW factors and by providing a well-refined framework. In addition, the transformation of this framework to an FCM allows revealing the individual impacts of each factor on the system and its relationships. As a consequence, the most influential HFW factors were uncovered, and contradictory results were resolved.

Second, this research provides practical contribution by comparing HFW interventions on a consistent base formed by integrating theory, previous research findings, and expert opinion. The findings of this study point to the most effective alternatives among many other, therefore, inform the efforts of designing and developing new interventions as well as improving existing ones.

Third, through a three-stage methodology, this study untangles the complexity of HFW factors by reflecting the complexity as it is rather than simplifying it. This methodology brought broad inclusivity of a great number of multifarious factors, therefore, a more complete representation of complexity. In addition, through an original technique, both the extraction of factors and their relationships were done through the content analysis of previous research findings. In this respect, the study offers an FCM that is unspecific to a context.

1.6 Overview of the Thesis

Chapter 2 summarizes FW literature by focusing on points influencing the research most, submits the rationale for why this study focuses on HFW, discusses social practices as the theoretical framework and the complex nature of HFW drivers, finally, examines the literature based on HFW reduction efforts. Chapter 3 introduces FCM, justifies the selection of the method, and explains the three-staged methodology framed for this research. Chapter 4 introduces the main findings of the study under the following themes: HFW system concepts and causal relationships, FCM constructed with these concepts and structural indices, and results of scenario analysis carried out with HFW reduction solutions proposed in the literature. Chapter 5 integrates and discusses the findings as well as the theoretical, methodological, and practical implications, limitations, and possibilities for future research.

CHAPTER 2: LITERATURE REVIEW

This chapter summarizes food waste literature by focusing on points influencing the research most. First, the main concepts and categorizations used in the literature were introduced to facilitate the understanding of the following sections. Then, the economic, social, and environmental consequences of food waste were discussed to show the significance of the phenomenon. A short review of food waste amounts throughout the world was presented thirdly. After exploring the root causes of food loss and waste throughout the food supply chain, the rationale for why this study focuses on household food waste was submitted. Following this introduction to the food waste phenomenon, social practice theory shaping the discussions around household food waste was discussed. Then, the complex nature of household food waste drivers was discussed. Finally, an examination of literature based on HFW reduction efforts was introduced.

2.1 Main Concepts and Categorizations

Food Supply Chain (FSC) is an important concept for the discussion of food waste because it bounds food waste definition as well as investigations regarding food waste amounts and causes. FSC demonstrated in Figure 1 is divided into five stages: i) agricultural production, ii) postharvest handling and storage, iii) processing and packaging, iv) distribution and v) consumption (Gustavsson et al., 2013)

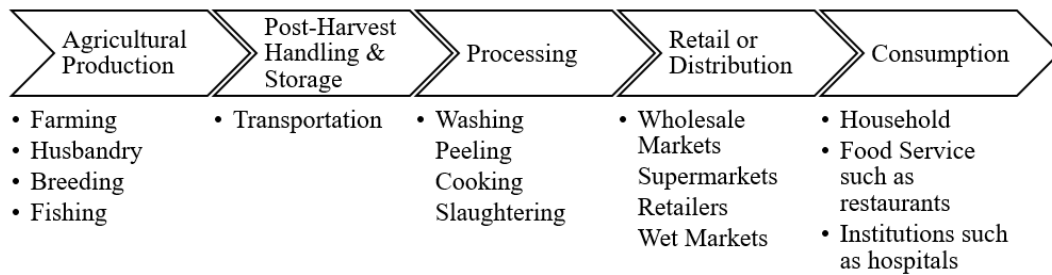


Figure 1 Food Supply Chain

(Adapted from Gustavsson et al., 2013; Papargyropoulou et al., 2014)

Thyberg and Tonjes (2016) pointed out the challenge raised by the lack of consensus on food waste definition, and they provided a food waste definition history. The definition has changed from time to time or from study to study with i) the exclusion or inclusion of food's edibility, ii) the FSC stage from which the waste generated, iii) the fact that to whom the food is produced and iv) by whom the food is consumed or degraded in the end. In another study, this issue was also attached to the difficulty of comparing the findings of studies conducted in different countries (Garrone et al., 2014).

According to the definition of FAO (1981), food waste is '*wholesome edible material intended for human consumption, arising at any point in the FSC that is instead discarded, lost, degraded or consumed by pests*'. Stuart (2009) specifies the usage of edible food for purposes other than human consumption such as feeding animals intentionally or obtaining by-products through food processing. Fusions dilate upon the fact that if the animals, fed with the food directed from human consumption, stay as part of the human food chain, then it can be excluded from the definition of food waste (Stenmarck et al., 2016). The conditionality of foods that are produced for human consumption excludes the material for other purposes such as crops for biofuels (FAO, 2011). The extent of the definition changes also according to when a material is deemed to be 'food'. In this case, since before harvest or slaughter material does not become food yet, losses occur in the former stages such as losses due to weather conditions might not be included (Lipinski et al., 2013). Finally, Parfitt (2010) enlarged the scope by defining the over-nutrition¹ as a sort of food waste.

¹ "The difference between the energy value of consumed food per capita and the energy value of food needed per capita"

In 2013, the definition narrowed down to food appropriate for human consumption that is discarded generally at retail and consumption stages (FAO, 2013a). This revived the distinction between food waste (FW) and food loss (FL). If edible food mass decreases throughout FSC stages; agricultural production, post-harvest, and production, it is called FL. The key aspect in this definition is that lost food mass would be transformed into edible food for human consumption if it could continue its journey along with the FSC (Gustavsson et al., 2013). The food mass loss, experienced after the transformation has been accomplished, is called FW. The main differentiating point of FL from FW is that it usually does not occur on purpose. Residues, faulty batches, analysis samples, or by-products that cannot be recovered for human consumption are examples for FL (Parfitt et al., 2010). Thyberg and Tonjes (2016) depict the difference between FL and FW with Table 1 shown below. For this study, the focus was FW, and the definition of FW provided by Table 1 was acknowledged.

Table 1 Food Waste vs. Food Loss Definition

Term	Definition	Drivers	Sectors Included	Examples
FL	Decrease in edible food mass throughout the part of the FSC that would produce edible food for human consumption	Infrastructure limitations Environmental factors Quality, esthetic, or safety standards	Agricultural production, post-harvest, and production	Edible crops left in the field Food that spoils due to poor transportation infrastructure
FW	Food which was originally produced for human consumption but then was discarded or was not consumed by humans. Food that is both spoiled and edible when it is thrown away	Decisions made by consumers and businesses Quality, esthetic, or safety standards	Retail and consumption	Plate waste Food prepared but discarded due to lack of demand Food that spoils due to poor storage in-home or restaurant

(Adapted from Thyberg & Tonjes, 2016)

As discussions around how the impacts of FW can be minimized have taken an important place in the domain, Food Waste Hierarchy (FWH) is another concept

that should be clarified. There are two approaches: waste management and waste prevention. The waste management approach considers FW as a biodegradable source to produce energy (Salihoglu et al., 2018). However, Papargyropoulou et al. (2014) propose a more holistic approach adopting a stepwise resolution of the food waste issue. The basis of this approach is the prioritization of FW prevention through the minimization of food surplus. FWH shown in Figure 2 is a guideline to formulate strategies focusing on obtaining the best environmental option. It starts with the prevention of surplus food generation and continues with re-distribution of surplus food for human consumption, recycling into animal feed, recovering energy when it is impossible to avoid waste and ends with the disposal. The main objective is to minimize the amount of unavoidable food waste that goes into landfills and solve the problem at the surplus generation point (Papargyropoulou et al., 2014).

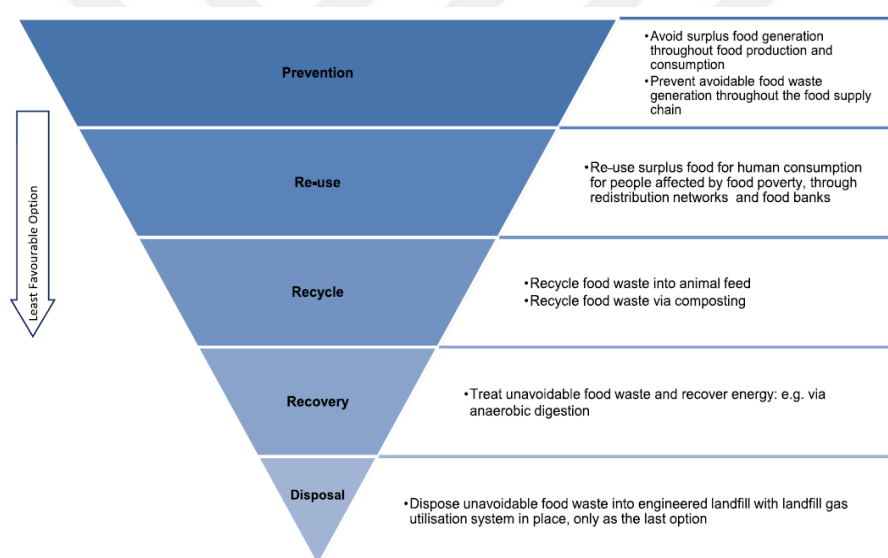


Figure 2 Food Waste Hierarchy

(Reprinted from Papargyropoulou et al., 2014)

2.2 Impacts of Food Waste

The most given statistics to depict the importance of food waste (FW) phenomenon are; one-third of all food produced in the world is wasted (FAO, 2011), growing world population will reach 9 billion people by 2050 and food must be produced to meet the growing needs (Gobel et al., 2015). Moreover, due to increasing urbanization and wealth level, the global population is prone to consume more

diversified diets and resource-intensive foods such as meats and dairy. This global demand growth, estimated to be continuing for at least 40 years, leads to the overutilization of land, water, and energy. These issues revive the notion of a sustainable food system to increase food availability as well as to minimize environmental impacts (Thyberg & Tonjes, 2016). To achieve a sustainable food system, food waste reduction is essential due to its economic, environmental, and social implications (Gobel et al., 2015).

FW has serious economic impacts. (FAO, 2013a) estimated the global food waste in 2007 as 750 billion USD. The value of FW generated each year in American households is 48.3 billion USD (Yıldırım et al., 2016). In UK homes, the value of FW is approximately 12 billion pounds (Quested et al., 2011). Papargyropoulou et al. (2014) highlight the relationship between food waste and food prices. According to them, reducing food losses throughout the FSC by increasing efficiency could be one way of reducing the cost of food. The cost of the food includes final waste disposal costs as well as purchasing costs. As a result of cost reduction, access to food that is nutritious, safe, and affordable would be increased for the consumers who are affected by food poverty (Papargyropoulou et al., 2014).

The inequality between food poverty and wasteful behaviors (Evans, 2012) brings the social implication of food waste; the moral aspect, into the picture (Papargyropoulou et al., 2014). Garrone et al. (2014) emphasize that food insecurity is a substantial challenge for developing countries. According to (FAO, 2013a), while in developing countries over 820 million undernourished people live, this number for developed countries is 15.7 million. Since food security has two dimensions; i) food availability and access and ii) food safety, the global strategy should focus both on increasing sustainability by reducing FW throughout the FSC and alternative diets such as reduction of meat content (Garrone et al., 2014; Papargyropoulou et al., 2014).

The environmental impact of food waste primarily emanates from its disposal in landfills which causes methane and carbon dioxide production and eventually contributes to climate change since they are greenhouse gases (GHGs) (Papargyropoulou et al., 2014). So, food waste is responsible for large emissions of

GHGs (Quested & Johnson, 2009). In addition, when edible food is wasted, all the resources depleted to produce that food would be wasted as well (Gustavsson et al., 2013). Kummu et al. (2012) estimated that 24 of freshwater, 23 percent of cropland, and 23 percent of fertilizer, used for the production of food lost or wasted globally. In addition to resource depletion, each FSC stage (processing, transportation, storage, etc.) has an embedded GHG impact which is transferred and accumulated as the food continues its journey (Papargyropoulou et al., 2014). In a study in the UK, it is calculated that food waste reduction can reduce GHG emissions by 456 million tons up to 2050 (Barrett & Scott, 2012). Göbel et al. (2015) shared the information gathered from the EU commission to depict the environmental impact of FSC. In the EU, FSC is accounted for 17% of GHG emissions and 28% of resource depletion.

2.3 Food Waste Amounts Throughout the World

In this section, FW corresponds to both food loss and waste generated throughout the whole FSC. When FW amounts throughout the world were investigated, an apparent disparity (see Figure 3) between developed and developing countries was standing out (Thi et al., 2015). The total amount of FW in Europe and North America is 95-115 kg/year per capita, whereas in Sub-Saharan Africa and South/Southeast Asia total FW amount is 6-11 kg/year. Scholars explained the difference with higher income levels in developed countries (Thi et al., 2015).

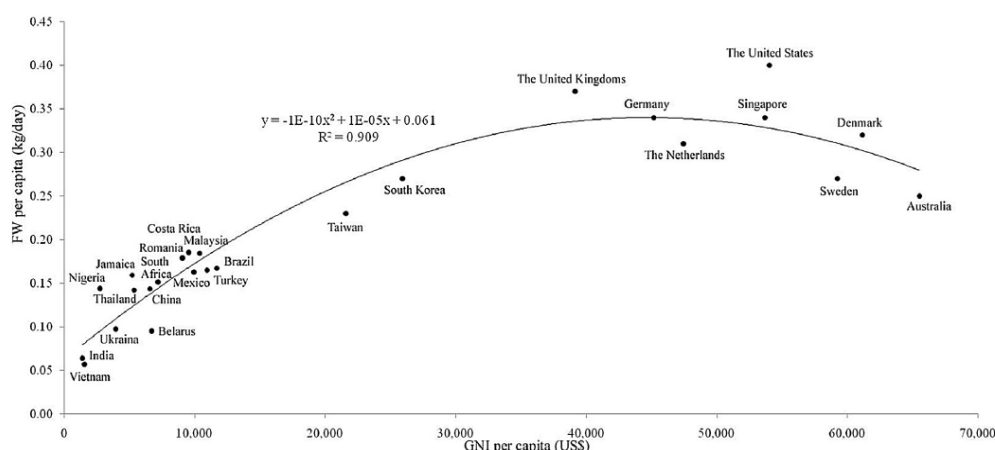


Fig. 1. Relationship between GNI per capita and FW per capita in some countries.

Figure 3 Relationship between GNI and FW

(Reprinted from Thi et al., 2015)

Another obvious distinction between developed and developing countries is the stage in which the FW is generated most. According to the world resources institute report (WRAP, 2013), in industrialized countries, the consumption stage is responsible for half of the total waste. In developing countries, on the other hand, two-thirds of food lost in the first stages of FSC. According to the report released by EU-Fusions (Stenmarck et al., 2016), the estimation for total food waste amount across Europe was 88 million tonnes that correspond to 20 % of the total food produced. With 47 million tonnes, households among all stages of FSC contribute most to this amount. WRAP (2020) estimates the total amount of food waste in 2018 in the UK as 9.5 million tonnes 70 % of which was generated by households. In line with these statistics, consumers in developed regions have been regarded as the main contributor to the FW generated all over the world (Bravi et al., 2020).

2.4 Causes of Food Loss and Food Waste Throughout the FSC

In the literature, FL and FW causes are commonly identified concerning the FSC stages in which the waste is generated. Since the FW is generated at the retail and consumption stages, the main causes are related to consumers' expectations and behavioral issues. FL, on the other hand, is related to infrastructural problems at the initial stages (Parfitt et al., 2010). Causes of FL and FW throughout the FSC were summarized in Figure 4.

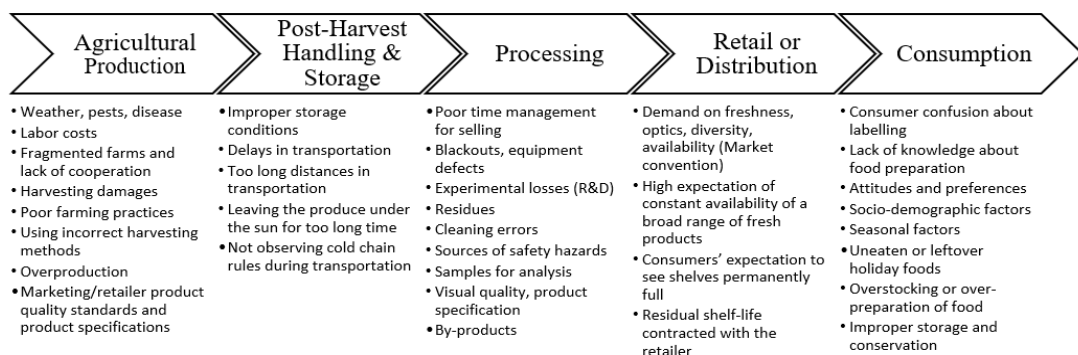


Figure 4 Causes of Food Loss and Waste throughout the FSC

(Adapted from Beausang et al., 2017; Gobel et al., 2015; Parfitt et al., 2010; Raak et al., 2017).

The key point in this categorization, consumers' demands, and expectations are prevalent in almost all stages other than consumption. Beausang et al. (2017) examined the primary production in the context of soft fruit and vegetables. They specify the root causes of FL under 6 categories: pest and disease, cosmetic specifications, weather, supply and demand, harvest, and storage. Among them, cosmetic specifications are determined by consumers' preferences. If those specifications are too strict, the amount of food nonconforming them and consequently lost will increase. Similarly, identifying the causes of FL in the processing stage, Raak et al. (2017) included external requirements such as product specifications and quality demands determined by consumers' suboptimality perception. The expectation of perfect appearance leads to rigorous controls in the elimination of quite normal but out of desired criteria. This effect was studied by Göbel et al. (2015) as well. They found out that consumer expectations and preferences such as visual appearance (faultless quality) and demands on freshness, optics, availability, and diversity lead to FL even at the first stage of FSC. Therefore, consumers' preferences, perceptions, and demands do not cause just FW generation at consumption stages but also FL generation at agricultural productions, processing, and retail stages (see Figure 5). In this regard, decisions made by consumers have a broad impact area within the FSC.

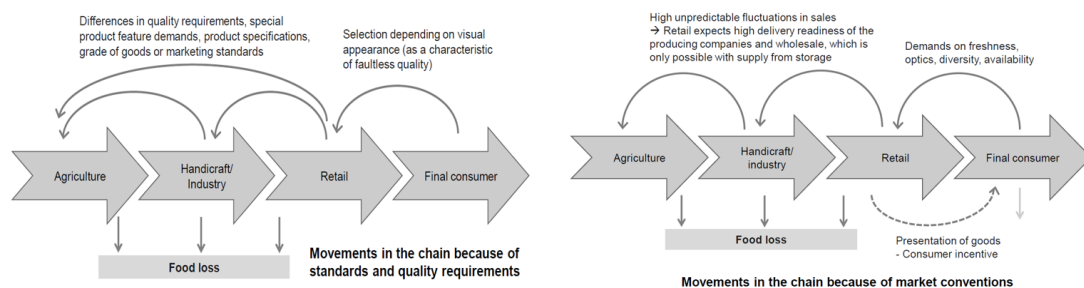


Figure 5 Movements in FSC

(Reprinted from Gobel et al., 2015).

On the contrary to the studies that examine causes concerning dynamics of FSC and interaction between stages, Thyberg & Tonjes (2016) accentuated the fact that food waste is a function of macro factors such as cultural, political, geographic, and economic. These factors are affecting wasteful behavior because they have a determining role in the nutritional transition and FSC change pace in a country. So,

the extent of industrialization, urbanization, economic growth, and globalization, which are the associations of FSC modernization, impact the wastage patterns of a society. For instance, as the level of industrialization increases, the frequency of food preparation and consumption at home decreases, and people tend to buy more pre-made food or eat at restaurants and start to drift away from food production and preparation. As a result, they put less value on food. Eventually, the point of FW generation and quantity of FW change from time to time or from society to society (Thyberg & Tonjes, 2016).

This general overview of reported FW amounts and root causes throughout the FSC has influenced the thesis focus. Since households have been reported as the most influential agents in the FW generation, not just in the consumption stage but also in the prior stages of the FSC, most importantly, through behavioral aspects, I decided to concentrate on HFW. Narrowing my gaze into households, I further review the literature investigating why people waste food in households. It is well known that social practice theory has informed this line of inquiry to the utmost. Thus, the next section expands on principles of the practice theory and how they were addressed for research on consumption, behavior change towards sustainable manner, and household food waste.

2.5 Theoretical Framework

For the exploration of why human beings waste food, social practice theory offers the most satisfying framework in the literature. Schatzki (2002) wanted to draw the attention of the contemporary academician to ‘practices’ by referring to key proponents such as Bourdieu and Giddens. According to Reckwitz (2002), practice theory is a specific form of cultural theory and presented as an alternative to others; culturalist mentalism, textualism, and intersubjectivism. Similarly, Schatzki (2002) identified the motivation underlying the movement towards the practice approach as opposed to current ways of thinking such as individualism, intellectualism, and many strains of humanism and poststructuralism.

Due to this multiplicity of oppositions, a consolidated approach is lacking. Even though theories of practices are heterogeneous, Schatzki and Reckwitz

committed to refining the prominent characteristics (Warde, 2005) without having any concerns of contrasting or asserting their superiority (Schatzki, 2002). As their attempts have appealed for the analysis of consumption, first, the main features of practice theory are compiled by referring primarily to their works. Thereafter, how these characteristics were interpreted as a promise for the study of consumption – especially sustainable consumptions and behavior change – is commented. Finally, why practice theory is a fruitful framework to adopt in the analysis of household food waste behaviors is dwelled on.

Practices such as political, cooking, religious practices, and educational practices engrave social life. This fact was the genesis for Schatzki and he defined practices as a “bundle” of activities, an organized nexus of actions (2002, p. 71). According to him, one of the two core notions of practice is ‘practice as a coordinated entity’. As doings and sayings are coordinated through essential elements, practices are formed and constitute a nexus (Schatzki, 1996, p. 89). Similarly, Reckwitz (2002) illustrated practices – way of consuming, of cooking, etc. – as blocks whose existence requires the interconnection of several elements. Schatzki (2002) asserted three major heads; 1) practical understandings of what to say and do 2) rules, principles, and instructions, and 3) teleoaffective structures subsuming ends, projects, tasks, purposes, beliefs, emotions, and moods. Reckwitz (2002) indicated forms of bodily and mental activities, ‘things’ and their use, background knowledge in the form of understanding, know-how, states of emotion, and motivational knowledge as the necessary elements. Shove and Pantzar (2005) adverted concisely that materials, meanings, images, and forms of competence embody the practice. It is important to keynote that practices are arrays of human bodily and mental activities but include those of non-humans/things/materials as well (Reckwitz, 2002; Schatzki, 2002, p. 11). Even though scholars use different typologies to define the key elements, they met in the common ground of the cruciality of the grift structure of elements to form practices.

Coordination of doings and sayings by requisite elements form practices but their presence needs performance. This brings us to the second core notion of practice theory: ‘practice as a performance’ (Schatzki, 1996). Routine reproduction of the nexus is a necessary condition for the existence of practices (Shove & Pantzar, 2005).

Therefore, a 'practice' is a routinized type of behavior or a pattern that can expand with myriad actions reproducing it (Reckwitz, 2002). Routinization and habitual nature may evoke that those practices compose only regular sayings and doings. Substantially, they are temporally evolving (Schatzki, 1996) and incorporate constantly changing as well as regular doings and sayings (Schatzki, 2002). Thus, another significant feature of practices is their dynamism as the way we engage in our daily lives is changing constantly over time and place (Sahakian & Wilhite, 2014). Moreover, the role of the single individual as a performer should also be brought into the picture because the inherent dynamism of practice stems from its dependence on who does it as well as when, where, and how it is done (Shove & Pantzar, 2005).

The single individual is the carrier of practice as a bodily and mental agent. Routinized ways of understanding, knowing how, and desiring that a performer follows is one of the fore-mentioned necessary determinants of practice but not the properties of the carrier (Reckwitz, 2002). This aspect unfolds the following discussion regarding the focus of practice theory in the analysis of social. Practice approaches notify a different conception. Instead of putting individuals into the center while defining social (Schatzki, 2001), practice theory takes practices as the smallest unit of analysis (Reckwitz, 2002). In practice theory, "*Social is a field of embodied, materially interwoven practices centrally organized around shared practical understandings*" (Schatzki, 2001: p. 12). With this feature, practice theory is neither individualist nor holistic but provides an alternative 'pluralistic and flexible' way of demonstrating social life (Schatzki, 1996: p. 12). Opposing to individualist and non-individualist accounts, practice theory refers to both social order and individuality as results of practices (Schatzki, 1996: p. 13).

Therewith Schatzki's positioning practice theory neither individualist nor holistic, Warde (2005) ascertained a promise for the research on consumption. The reason for the attraction was that practice theory does not repose the assumptions: superiority of individual choice, rational action type, and personal identity expression. His main argument is that since it is an indispensable part of daily life, consumption is encompassed by most practices even though it is not itself a practice. From this perspective, consumption is a process whereby agents engage in appropriation and appreciation of items, and traditions of the practice regulate this process. The primary

interest of the consumption studies – differentiations, and similarities within and between groups of people – is a natural consequence of how a practice is organized. Rather than personal choices or tastes, the traditions, and standards of the practice orient the behavior. It is the practices that generate wants, not the individual desires. Consumption of a particular item is one of the elements of a practice that renders its performance possible. Therefore, *“It is the fact of engagement in the practice, rather than any personal decision about a course of conduct, that explains the nature and process of consumption”* (Warde, 2005: p. 138).

Leaving out the individual choices or taste does not purport that the agents perform consumption practices invariably. Sahakian and Wilhite (2014: p. 27) associated intergroup differentiation in the performance of practices with Bourdieu’s habitus. As an embodied history and dispositions, habitus can structure practices and can be structured by them in meanwhile within a dynamic relationship. Social and personal history, neglected in the notion of rational choice, is significant in the practice formation. Warde (2005) found it worthwhile to consider that social differentiation of practices and their performance built upon independent variation of key elements between groups of individuals. Since key elements – understandings, procedures, and engagements – diverge among agents, the nexus of doings and sayings formed employing these elements varies as well. Even though how these elements organize formally or informally determines the behavior within a practice, performance is neither fully conscious nor reflective. This situation enables the reproduction of that practice and makes the theory of practice a basis for behavior change through the development of practices (Warde, 2005). Therefore, he propounded that examination of how key elements are seized and accommodated to the performance of consumption practice by a particular group would be more productive than the analysis of individual decision-making.

Starting from this point of view, practice theory is found to be promotive for the research in behavior changes towards a more sustainable form (Evans et al., 2012; Sahakian & Wilhite, 2014). Evans et al. (2012) pointed out that the current entrance point to a more sustainable way of consumption is the problem of ‘sovereign’ consumers who choose to behave in an environmentally harmful manner. When the point of departure is individual choices, a desirable solution would be persuading

individuals to behave oppositely. Similarly, Sahakian and Wilhite (2014) criticized the dominant perspective that puts individual decision-making mechanisms at the center of behavior change discussions. From this perspective, technological advancements and cleaner production systems are targeted as ‘*silver bullet solutions*’ to reduce overconsumption and its environmental impacts. When these developments are applicable, individuals are deemed responsible and labeled as either ‘*barrier or catalyst to change*’ (Sahakian & Wilhite, 2014: p. 26). Evans et al. (2012) regarded practice approaches as an opportunity to review and change the entry point of behavior change initiative because they scrutinize unsustainable ways of consumption as “*embedded in the social ordering of practices*”. As a result, habits, and routines, the rhythm of everyday life, shared understandings of cultural and technical competence are the center of the attention paid (Evans et al., 2012: p. 114). Change in point of departure – practices as the principal unit of analysis – induces a change in how the problem is conceptualized and the objective as reconstructing the organization and performance of practices. Evans et al. (2012: p. 121) explicated their account with this paragraph:

“A practice-based approach to developing more sustainable forms of food consumption requires a focus on the systems of food provision and recognition that there are many interconnected practices that makeup and contribute to the practice of eating. Such inter-connected practices include acquisition (where, when, and how people acquire food), food storage, methods of cooking and food preparation and, the ways in which surplus and discarded foodstuffs are disposed of. It follows that efforts to develop more environmentally sustainable eating practices require interventions that address the inter-connected activities that together form the practice”.

Moving from these accounts, they analyzed some cases that explicitly aimed to change behavior and reached some key points to consider while designing policies drawing on practice theories. The most important one is that intervention should target multiple activities or elements that structure a practice since the practices as a coordinated entity are “bundles” of activities. Sahakian and Wilhite (2014) also highlighted the requirement of addressing multiple elements to alter the inflexible nature of habits. Habits such as how we shop for food and how we clean our homes are “*recurrently and consistently reproduced by suitably committed practitioners*”

(Shove, 2012: p. 103), deeply embedded in habitus and therefore stubborn to change (Sahakian & Wilhite, 2014: p. 28). Thus, to transform a habitual practice into a more sustainable way, fighting against more than one aspect is a prerequisite.

Identification of the most influential aspects is another key issue. The main corollary behind the account is power inequality between the elements of practice. If the agency power of some elements is more remarkable than others, their capacity to change practice would also be more significant. Moreover, the “rebound effect” is a hidden danger that should be acknowledged (Sahakian & Wilhite, 2014: p. 39). This term is used for the unanticipated perverse effect of a change in one practice. Through an intervention, a significant reduction in one consumption domain could be achieved but the same intervention might lead to an increase in another. Therefore, since practices are interrelated, they must be regarded as a system, and concentration on a specific practice should be avoided. After all, the main objective is to design the most effective intervention.

Based on all these accounts, in the discussion of household food waste, Evans (2011) emphasized that positioning individual decisions or choices as the source of the problem and changing them as the unique solution is an overly simplistic approach. With an ethnographic study conducted in the UK, he manifested that food waste is generated as a consequence of socially organized domestic food practices. Individuals make decisions and behave accordingly by negotiating contingencies within this social organization comprising various elements: food safety and healthy eating concerns, family relations, socio-temporal context, tastes, domestic technologies, the infrastructure of provisioning, and organic vitality of food. Their attitude towards wasting food and lack of knowledge or awareness solely are not indicators of the resulting behavior of wasting food. He provided evidence of circumstances in which respondents came to the instance of wasting food even though they were regardful for food or knowledgeable enough to manage food (Evans, 2011).

Departing from the same account – increase in the level of knowledge and awareness may not change wasting behavior – Hebrok and Heidenstrøm (2019) offered a contextual approach to household food waste prevention. They argued that HFW reduction interventions could achieve significant results as long as they target

actual food handling practices prevalent in waste generation. They figured out decisive moments within the network of intertwined practices that should be addressed by preventive measures. From this perspective, knowledge and awareness campaigns fall short of producing compelling outcomes.

Social practice theory is not the only framework held in the inquiry of household food waste behavior but offers the most rewarding framework compared to others. For instance, climate change policies built upon the ABC (attitude, behavior, choice) framework were criticized due to its dependence on individualistic perspectives (Shove, 2010). In the discussion of food waste, Evans (2011) shared the same account and remarked that the ABC framework supposes food waste is a consequence of careless consumers and relies on the need for attitudinal change.

The theory of planned behavior (TPB) (Ajzen, 1991), on the other hand, is the most widely used framework to provide possible causes of household food waste behavior except social practice theory (Barone et al., 2019; Russell et al., 2017; Schmidt, 2019; Soorani & Ahmadvand, 2019; Stancu et al., 2016; Stefan et al., 2013). In this model, intention is the main determinant of behavior whose antecedents are attitudes, subjective norms, and perceived behavioral control. Even in this domain, scholars acknowledged that food-related household practices constituting many interrelated decisions cannot be exempted and extended their model with related constructs to gain more explanatory power. Stefan et al. (2013) presented that intentions not to waste food did not significantly affect consumers' food waste while planning and shopping routines, on the other hand, did. The main argument they proposed to explain this result was that food waste is a consequence of everyday routines performed by consumers rather than a consequence of conscious intentions of not to waste. Stancu et al. (2016) strengthened the position stating that waste behavior is not under strong volitional control. Similarly, they found that shopping and leftovers reuse routines were more predictive than intentions not to waste.

By acknowledging the social practice theory as the most useful framework for the inquiry, the focus of the literature review narrowed to empirical studies investigating HFW drivers through a practice lens. However, since HFW drivers were presented in length and breadth as research findings in Chapter 4, the next section was

allocated for the discussion on the complex nature of HFW drivers and methodological limitations to untangle this complexity.

2.6 Complex Nature of Household Food Waste Drivers

The general climate of opinion prevailing in the literature of HFW drivers highlighted the high level of complexity. Complexity fundamentally emanates from a great number of wide-ranging and interacting factors that are directly or indirectly affiliated with HFW (Roodhuyzen et al., 2017).

Many scholars (e.g. Aschemann-Witzel et al., 2015; Evans, 2011; Porpino et al., 2015; Sosna et al., 2019; Urrutia et al., 2019) have identified a wide range of HFW-generating intertwined food-related practices – planning, shopping, storing, preparation and serving, assessing edibility, consumption, leftover managing, redistributing and disposal (Roodhuyzen et al., 2017; Schanes et al., 2018) – that are habitual (Reckwitz, 2002), therefore, stubborn to change (Sahakian and Wilhite, 2014). The nexus of food-related practices are formed by the gift structure of essential elements (Reckwitz, 2002; Schatzki, 1996; Shove & Pantzar, 2005) such as attitudes, preferences, concerns, materials, food/package/retail properties, socio-temporal factors, knowledge, skills, and awareness. When Roodhuyzen et al. (2005), through a systemic literature review, gathered all of those practices and elements together, came up with a long list constituting 116 factors.

Apart from the great number of factors, the multifaceted nature of the causal web formed between those practices and elements is the second fold of the complexity. Roodhuyzen et al. (2017: p.48) conceptualized consumer food waste as a “*cumulative result of different causal sequences (pathways) of interacting factors*” which means that a factor by following different pathways might lead to different consequences. This fact manifests itself in the literature with contradictory arguments regarding the relationship between some factors and HFW. For instance, poor planning was displayed mostly as a driver of HFW (e.g. Farr-Wharton et al., 2014; Janssens et al., 2019; Mattila et al., 2019; Porpino et al., 2015; Stefan et al., 2013). However, it was also revealed that strict – long-term planning (opposite of poor planning) increases the HFW due to the inability to respond to unforeseen events

(Hebrok & Heidenstrom, 2019; Urrutia et al., 2019). In addition, others (e.g. Bravi et al., 2020; Elimelech et al., 2019; Giordano, Alboni, & Falasconi, 2019; Stancu et al., 2016) found no relation between poor planning and the amount of food wasted.

The root cause of a factor having such controversy might also be its distance from the main action or decision point through which food is wasted (Hebrok & Boks, 2017). In-between shopping planning and disposing of food, consumers perform many practices through which they can compensate negative consequences of pure planning as well as cannot remunerate strict planning. Furthermore, multiple pathways might explain why consumers could not clarify the reasons for wasting food even if they intend not to waste it.

Being distant from the moment of wasting does not make a factor less important. On the contrary, the existence of countless pathways having a disparate influence on the outcome requires the investigation of the behavior of all factors together. Therefore, the cumulative outcome of interacting factors can be observed. This could be achieved through a systematic approach that was proposed as essential for designing effective interventions. Sahakian and Wilhite (2014) emphasized i) addressing multiple elements, ii) targeting the most influential factor, and iii) grabbing rebound effects for an intervention to alter entrenched practices. To achieve these three items, the complex system of HFW factors should be demonstrated with a large range of significant factors, all possible relationships between them, and their relative strength. Previous studies, on the other hand, have failed to address this need due to methodological limitations.

Methods used by the growing body of literature examining HFW drivers were either qualitative (e.g. Dobernig & Schanes, 2019; Farr-Wharton et al., 2014; Mattila et al., 2019) (e.g. interview, participant observation, focus group, ethnographic) or quantitative (e.g. Giordano, Alboni, Cicatiello, et al., 2019; van Dooren et al., 2019) (e.g. questionnaire, survey, experiment). Providing an in-depth understanding of interconnected relationships of multifaceted factors, qualitative studies accomplished to reveal causal mechanisms. From this respect, they provided the most complete narrative (Hebrok & Boks, 2017). However, they could not or attempt to quantify, therefore, to prioritize the factors and pathways. Quantitative studies could close this

gap by examining the relationship between factors and HFW amount through statistical analysis. They, on the other hand, were incomplete as they concentrated on a subset of factors (Roodhuyzen et al., 2017). Incompleteness might stem from the abstract nature of factors that creates a challenge in measurement or concerns regarding being parsimonious. In addition, quantitative studies revealed the influence of individual factors rather than their combined effect, therefore, they are far from having a holistic view.

The complex nature of HFW drivers and incomplete representations of their causal web have brought along another challenge to be addressed. As the causes of HFW are multifarious, wide-ranging solutions to HFW reduction have been proposed whose effectiveness has come under question in the literature (Reynolds et al., 2019; Schanes et al., 2018; Stockli et al., 2018). Roodhuyzen et al. (2017) argued that understanding the multifactorial and complex nature of HFW drivers is a prerequisite for the development of this line of inquiry. In this context, the primary aim of this thesis is to provide a more complete representation of causal mechanisms behind HFW drivers that would be rewarding for the analysis of HFW-reducing solutions. In addition, Hebrok and Boks (2017) made a call for finding new ways to test interventions recommended for HFW reduction. Reynolds et al. (2019) added the need for greater integration of theory and previous research findings into the investigation by adopting different methodological techniques. For this purpose, a distinctive method, fuzzy cognitive mapping, that allows addressing the reasons behind complexity as well as testing proposed solutions, was selected. Fuzzy cognitive mapping was chosen as a tool that can serve the function Reynolds et al. postulated:

“would it, for instance, be possible to combine a qualitative account of social practices that generate food waste with quantitative tools that model the effects of different interventions” (2019: p. 15).

The next chapter introduces the research methodology in detail and discusses the justification of method selection. However, before passing to the next chapter, the final section of this chapter touched on HFW reducing interventions covered under the scope of this study.

2.7 Household Food Waste Reduction Interventions

While deciding on which interventions to take into the scope of this study, the food waste hierarchy (FWH) proposed by Papargyropoulou et al. (2014) was considered. FWH is a guideline to formulate strategies focusing on obtaining the best environmental option. It starts with the most environmentally friendly option, the prevention of surplus food (reduce), and continues with reuse and recycle options. The main objective must be to solve the problem at the first step because as the food continues its journey, the environmental degradation it causes incrementally grows. From this respect, only the solutions aiming to reduce food surplus are tested within the scope of this research. Even though the reuse and recycle options are vital to holistically fight the environmental consequences, they do not address the root causes of HFW generation. Similarly, Urrutia et al. (2019) dwelled on that a policy approach should not canalize to rescuing the surplus generated due to unsustainable systems. Therefore, the redistribution of the surplus to the ones in need through food banks (Baron et al., 2018), waste management alternatives (e.g. biogas generation), and top-down policy implementations to orient FW away from landfills (Chalak et al., 2016) were excluded. The remaining solutions addressing household food-related practices can be classified as informational campaigns, new food provisioning systems, and technological innovations. They were introduced by referring to both academic literature and grey literature.

Informational campaigns such as “Love Food Hate Waste” (LFHW, n.d.) are the most frequently used intervention method to fight against HFW (Hebrok & Heidenstrom, 2019; Stockli et al., 2018). It was acknowledged that lack of knowledge, skills, and awareness is an antecedent of many activities correlated with HFW. Therefore, campaigns aspired to improve consumers’ level of knowledge, skills, and awareness by providing them tips and techniques (Reisch et al., 2013; Zamri et al., 2020) on those activities that are key to HFW reduction such as cooking with leftovers (Dobernig & Schanes, 2019; Schanes et al., 2018), assessing food’s edibility (Hebrok & Heidenstrom, 2019; Mattila et al., 2019), and accurate interpretation of date labels (Aschemann-Witzel et al., 2015; Farr-Wharton et al., 2014). Another aim is to create awareness about the negative consequences of food

waste in general. FAO regards raising public awareness as a driving force for the whole food industry to take action against FW (FAO, 2013b).

On the other hand, some scholars (Evans, 2011; Hebrok & Heidenstrom, 2019) criticized the current focus on informational interventions since they target individuals as responsible rather than their contextual everyday food-related practices. They underlined the cruciality of the social practice approach by identifying HFW as an outcome of a complex social process of both individual and non-individual factors. Raising information and awareness is not sufficient in changing behaviors since they do not address the factors outside the individual such as socio-temporal factors and the material conditions (Evans, 2011; Hebrok & Heidenstrom, 2019). According to Hebrok and Heidenstrom (2019), HFW reduction efforts should be associated with context-dependent food-related household practices that could not be achieved through information campaigns.

However, some information interventions utilizing innovative delivery methods rather than using solely standard channels such as social media, websites, brochures (Stockli et al., 2018; Zamri et al., 2020) might accomplish transforming key practices instead of just giving instructions and then expecting the individuals to perform them. Therefore, information interventions could also be promising in HFW reduction contrary to skeptical arguments. One example is 'Hellmann's Restaurant with no Food' (Ogilvy, n.d.) initiated in Brazil whose primary objective was still raising awareness and improving culinary skills but through a more engaging approach. Because the leftovers and the lack of motivation of putting them into use is one of the primary drivers of HFW, this restaurant asks people to bring their leftovers and turns them into a five-star meal by professional chefs. People, who have difficulty in using up the food they have, are demonstrated by the fact that meals cooked with their leftovers could be transformed into tasty meals. Therefore, the main difference of this initiative from other campaigns was putting instructions into practice within the context of targeted individuals.

The second example proposed by FAO (2013b) was targeting poor and vulnerable households in again Brazil named SESI's Programa Cozinha Brasil (Brazilian Kitchen Program). Through mobile learning kitchens, the program teaches

participants to prepare affordable, nutritious, and tasty regional meals whose recipes are offered by nutritionists and chefs. While fighting against lack of knowledge/skills/awareness, through hands-on training, the program could address wasteful practices such as cooking too much or leftover generation proved to be effective in HFW generation. In addition, considering regional tastes and reaching targeted individuals in their locations, this program had a contextual approach.

The next category of proposed HFW reducing interventions constitutes alternative food provisioning systems. Scholars (Dobernig & Schanes, 2019; Evans, 2012; Hebrok & Heidenstrom, 2019) have argued that addressing food store structure as a material context having a high impact on food-related practices could yield significant HFW reduction. Their argument was underpinned by the evidence of store structure elements' – such as special offers (Graham-Rowe et al., 2015; Mattar et al., 2018; Wansink, 2018), the magnitude of food store (Fanelli, 2019; Jörissen et al., 2015), and large package sizes (Aschemann-Witzel et al., 2015; Wikstrom et al., 2019) – impact on food-related household practices, especially on shopping practices. One of the alternatives was the farmers' market proposed as a promise to enhance the consumers' bond with the food's origin that has been detached. This current detachment leads to a depreciation problem that makes food wastage easier. Food products purchased from the farmers' market were supposed to be valued highly since consumers have the opportunity to have a direct relationship with food growers and learn about their practices, therefore, wasted less likely (Dobernig & Schanes, 2019). Furthermore, the farmers' market provided smaller assortments whose demand was ensured by customer loyalty, therefore, wasted less amount of food compared to conventional retailers (Ribeiro et al., 2019). In addition, an unintended outcome might occur due to an increase in the proportion of perishable products when a household purchases its food from the farmers' market.

Another example of alternative food provisioning systems is zero-packaged groceries proposed by FAO (2013b). By using their own reusable containers, customers primarily contribute to the reduction of single-use food package waste. The center stage for this research, on the other hand, this business model's potential in transforming food-related household practices causing HFW. FAO (2013b) argued that these groceries could address the problem of purchasing more than needed that

causes HFW by allowing customers to decide on how much they are going to purchase. The transition of this responsibility to consumers would push them to make strict planning that was regarded as an HFW reducing influence (Beitzen-Heineke et al., 2017). However, some consumers might find this way of shopping burdensome as it is time and effort-consuming (Marken & Hörisch, 2019). On the other hand, by giving too much time and effort during shopping, consumers might value more the food purchased from those groceries and become cautious about wasting it (Dobernig & Schanes, 2019; Hebrok & Heidenstrom, 2019; Porpino et al., 2016).

Apart from profound changes in food provisioning systems, relatively minor improvements within the conventional systems were also discussed to reduce HFW. One example could be Tesco's attempt to change the promotion type from multi-buy to mix-and-match to reduce wastage of a particular product. Moreover, online shopping was proposed as an HFW reducing way of practice since it was thought to be a motive for strict planning.

The final category includes technological advancements addressing material context (Evans, 2012), particularly fridges as domestic technology, and food packaging as food property (Hebrok & Boks, 2017). Intelligent fridges (Hebrok & Boks, 2017), intelligent packaging (Yam et al., 2005), and active packaging (Liegeard & Manning, 2020) are examples of those technological developments. Intelligent fridges were found promising (Hebrok & Boks, 2017) because they are going beyond just providing larger space or optimal storage conditions whose deficiency is commonly indicated as the cause of HFW. They can track the content of the fridge, alert regarding fridge content closer to expiry date together with a recipe, and prepare and send a shopping list (Bucci et al., 2010).

Intelligent packaging has introduced a new way of assessing the edibility of a packaged food as an alternative to best-before-date labels that are found confusing by consumers. Confusing date labels might lead to the early disposal of food that was still within the period of safe consumption. In addition, employing good storage practices, it might be possible to consume the food even after its expiry date since best before dates are identified against the worst scenario. Intelligent packaging monitors both internal and external conditions of the package and informs the consumer

regarding the edibility of the food (Yam et al., 2005). Through moisture control, liquid/oxygen/ethylene absorption, or preservation release, active packaging, on the other hand, plays a more active role. Therefore, differently from intelligent packaging, active packaging can extend the shelf-life of the food.

All the introduced HFW-reducing solutions were underpinned by grounding arguments; however, their effectiveness has been underexplored. Reynolds et al. (2019) discussed how costly a study investigating the consequence of an intervention. They proposed two ways for reliable measurement methods. The most commonly used method captures the waste amount through self-reported that was proven not to be parallel with actual food waste amounts (Elimelech et al., 2019). For this reason, using control groups was proposed which is a challenging and cost-increasing factor (Reynolds et al., 2019). The direct measure of waste amount through composition analysis would give the most accurate information regarding the effectiveness of an intervention. It requires, on the other hand, a longitudinal approach through which HFW amounts will be tracked regularly, therefore, requires receiving enough funding and building partner collaboration (Reynolds et al., 2019: p. 24). From this respect, introducing new approaches that can overcome the challenges faced with existing methods has great importance to decide which intervention should be made widespread. We argue that FCM has this potential since it provides a consistent base that can be underpinned by theory and previous findings and through which heterogeneous intervention alternatives can be tested and compared. The next chapter scrutinizes the method.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Fuzzy Cognitive Mapping

Kosko (1986) developed Fuzzy Cognitive Mapping as a tool to apprehend and model the complex causal-effect systems (Alizadeh et al., 2017). Complexity arises due to the large number of interwoven elements constituting the system as well as due to difficulty in understanding and solving this network (Nair et al., 2019). Furthermore, representing human behavior while modeling especially complex social systems brings an additional challenge that is the quantification of qualitative (abstract) concepts. To overcome these challenges the use of new scientific tools is requisite (Nair et al., 2019). At this point, FCMs are proposed to handle the complex social systems since they can demonstrate the system by approaching from the point of how human beings perceive the system (Papageorgiou & Salmeron, 2013). It is a method that represents a causal network between system concepts (Groumpos, 2010) that can be both quantitative (definitive) and qualitative (abstract) (Nair et al., 2019). System concepts, important variables that affect the system, are derived from the accumulated knowledge and experience of systems experts (Groumpos, 2010; Papageorgiou & Salmeron, 2013). The method is advantageous when the information is scarce (Morone et al., 2019) or uncertain and vague because it enables modeling such a piece of information by utilizing natural language created by human experts (Nair et al., 2019). It simply shows the behavior of this system as well as enables simulation (Groumpos, 2010). According to Jetter and Kok (2014: p. 45), by generating scenarios that establish a link between quantitative analysis and qualitative storylines, FCMs deserve to be included in the toolbox of future studies.

FCMs are graphical configurations that consist of nodes expressing concepts and directed arrows with weights connecting those concepts. An arrow, departing from a causing concept, shows the affected concept, and weight indicates the strength of this relationship. Before Kosko (1986) developed FCMs by adding fuzzy logic to cognitive maps (CMs), CMs did not take the relationship's strength into account. All relationships identified within a system were regarded to have equal impacts, and weights of directed arrows could be attained with values 0, 1, and -1. In FCMs, on the other hand, weights, as well as concepts, can have a value in between those numbers and are therefore fuzzy (Alizadeh et al., 2017; Papageorgiou & Salmeron, 2013). Weights can have three different meanings (Yaman & Polat, 2009).

- If weight has a value between $[0,1]$, then there is a positive causal relationship between the two concepts. An increase (decrease) in causing concept leads to an increase (decrease) in the affected concept.
- If weight has a value between $[-1,0]$, then there is a negative causal relationship between the two concepts. An increase (decrease) in causing concept leads to a decrease (increase) in the affected concept.
- If the weight is 0, then the causal relationship between the two concepts does not exist.

Kosko (1993) considered FCMs as a '*simple form of recursive neural network*' (Jetter & Kok, 2014: p. 46). When a fuzzy concept changes its state, a non-linear activation permeates through the FCM. Changed concepts convey the weighted activation directed towards them to others that are causally dependent on them. As FCMs enable feedback loops, activation between concepts continues until the system reaches an equilibrium state, a point in which all the concepts are fixed. It may take several iterations to reach that fixed point which means that a concept may be activated and subsequently change more than once (Jetter & Kok, 2014).

Figure 6 demonstrates a simple FCM sample consisting of five concepts. A concept is denoted with C_i with a state value A_i which can be a fuzzy value within $[0,1]$. The strength of the influence of the causing concept C_i on effected concept C_j is denoted with W_{ij} that can take any value within $[-1,1]$.

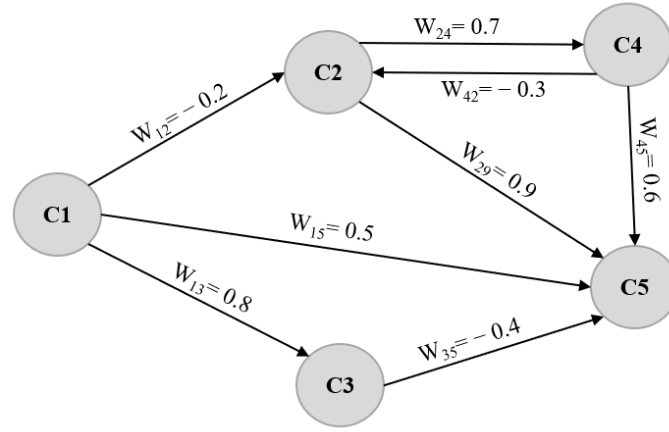


Figure 6 An FCM

The adjacency matrix corresponding to the FCM (fig. 1) is shown as follows.

$$W = \begin{bmatrix} 0 & -0.2 & 0.8 & 0 & 0.5 \\ 0 & 0 & 0 & 0.7 & 0.9 \\ 0 & 0 & 0 & 0 & -0.4 \\ 0 & -0.3 & 0 & 0 & 0.6 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad (1)$$

In this FCM, the value of each concept indicated by C_i ($i= 1, \dots, n$) is calculated with the following iterative equation (Groumpos, 2010). Iterative computation of concepts' values with equation (2) is the fundamental procedure of FCM theory called the running cycle of FCM (Groumpos, 2010).

$$\left(A_i^{t-1} + \sum_{j=1, j \neq i}^n A_j^{t-1} W_{ji} \right) \quad (2)$$

A_i^t represents the value of C_i at iteration t , A_i^{t-1} the value of C_i at iteration $t-1$, A_j^{t-1} the value of C_j at iteration $t-1$ and W_{ji} the weight of interconnection from concept C_j to concept C_i . f is a threshold function used to squash the results into normalized range (Papageorgiou et al., 2006). Threshold functions can be two types and are represented below.

$$f(x) = \frac{1}{1+e^{-\lambda x}}, (\lambda > 0) \quad (3)$$

$$f(x) = \tanh(x) \quad (4)$$

In equation (3), concept values are restricted to be continuous and within [0,1] (Mei et al., 2014). λ is a parameter that determines its steepness. In equation (4), on the contrary of equation (3), concepts can be negative, and their values can be within [-1,1] (Groumpos, 2010). In our approach, equation (3) with the value $\lambda = 1$ was used.

After having constructed an adjacency matrix and determined the type of threshold function, it is possible to simulate by creating an initial state for a concept that is indicated by the given scenario. For a scenario analysis, an initial state of 1 is attained to all concepts, and a steady-state calculation is done. Table 2 shows the result of the steady-state calculation of FCM in Figure 6. After the 8th iteration, any changes in the concepts were not observed. So, steady-state has reached in the 8th iteration.

Table 2 Calculation of Steady-State for FCM

Iteration	C ₁	C ₂	C ₃	C ₄	C ₅
0	1	1	1	1	1
1	0.7311	0.6225	0.8581	0.8455	0.9309
2	0.6750	0.5554	0.8089	0.7827	0.8829
3	0.6626	0.5463	0.7940	0.7634	0.8660
4	0.6599	0.5460	0.7899	0.7587	0.8617
5	0.6592	0.5465	0.7888	0.7579	0.8609
6	0.6591	0.5467	0.7885	0.7578	0.8607
7	0.6591	0.5467	0.7885	0.7578	0.8608
8	0.6590	0.5468	0.7885	0.7578	0.8608
9	0.6590	0.5468	0.7885	0.7578	0.8608
10	0.6590	0.5468	0.7885	0.7578	0.8608

Having obtained the steady-state values of concepts, then the iterative calculation can be done for a hypothetical scenario, and results can be interpreted by comparing with steady-state. Suppose a hypothetical scenario proposes an increase in 2nd concept. Then, to simulate the impact of this scenario, only C₂ is activated. Table 3 represents the results of the scenario analysis.

Table 3 Results of Hypothetical Scenario Analysis for the FCM

Iteration	C ₁	C ₂	C ₃	C ₄	C ₅
0		1.0000			
1	0.7311	1.0000	0.8581	0.8455	0.9309
2	0.6750	1.0000	0.8089	0.8243	0.9138
3	0.6626	1.0000	0.7940	0.8212	0.9107
4	0.6599	1.0000	0.7899	0.8207	0.9103
5	0.6592	1.0000	0.7888	0.8206	0.9103
6	0.6591	1.0000	0.7885	0.8206	0.9103
7	0.6591	1.0000	0.7885	0.8206	0.9103
8	0.6590	1.0000	0.7885	0.8206	0.9103
9	0.6590	1.0000	0.7885	0.8206	0.9103
10	0.6590	1.0000	0.7885	0.8206	0.9103

When values of concepts reached equilibrium, hypothetical scenario values can be compared with initial steady-state values. It can be concluded that:

- an increase in C₂ will increase the state of C₄ by 0.0628 (from 0.7578 to 0.8206) and the state of C₅ by 0.0495 (from 0.8608 to 0.9103).
- an increase in C₂ does not affect C₁ and C₃.

3.2 Justification of Selection

Fuzzy Cognitive Mapping is selected as a method primarily to untangle the complex network of HFW drivers. It provides promises to address the main reasons behind the complexity which could not be addressed with methods used thus far.

The complexity of the HFW system first rises from the high number of factors that were propounded to be effective in HFW generation. Discussions mainly target food-related household practices and routines starting with shopping and meal planning and end with disposal as the source of waste. The story, however, does not end here. There are many other drivers such as attitudes, concerns, or package and food properties that were brought up as important factors shaping those domestic practices and causing HFW. The number of factors, though, is not the only characteristic that makes the issue complicated. Interacting with each other, these factors form different pathways leading to HFW. Following different pathways, some factors could have both increasing and decreasing effects. When which pathway outweighs the other within a system is uncertain, it becomes challenging to decide

which one to address. Apart from the diverse impacts of a concept, the distance of a concept from the dependent variable is another basis of HFW system complexity.

Concluding that there is a direct relationship between a distant concept and HFW could be challenging. For instance, series of food-related household practices starts with shopping planning and continues with many others until the point that food is disposed of. It is possible to recover the possible negative consequences of poor shopping planning through better storage and cooking practices as well as it is possible to cause a serious amount of HFW subsequent perfect planning through poor storage practices. This does not mean that the planning routine is less important than the ones performed just before disposal. The most direct and apparent effect might not always be the most influential one when the issue of HFW is approached as a complex social system. On the contrary, the impact of a variable within a network could also be important even though there is a big gap between the variable and the dependent variable. After all blurred interactions occurred within the gap between a distant concept and dependent variable are unraveled, how significant a role of a distant concept could be demonstrated. So, rather than making an effort to establish direct links, the behavior of all concepts together within a complex system should be investigated.

As a natural consequence of variables having a diverse effect and distance, in the literature contradictory results were reported for a particular relationship. This fact appears as another strain of complexity. Finally, as human behavior is at the core of the social system representation, HFW system agents are mostly composed of qualitative (abstract) elements that are hard to measure.

Widely utilized methods, qualitative tools such as in-depth interview and participant observation, and quantitative tools such as surveys, fell short of providing completeness and prioritization at the same time. Qualitative studies provided a rich context that explicates a diverse range of pathways constituted by multifarious elements. They represented the most complete models in terms of an integrated range of factors and as well as causal relations between them. With this feature, the qualitative studies accomplished to capture interactions and left fewer gaps behind. Studies utilizing qualitative methods, however, do not have an urge to quantify and

prioritize the importance of the factors or the strength of interactions. Furthermore, they could be context-dependent and clear of generalization. Quantitative methods could address those limitations and provide statistical analysis of causal relations between variables for larger samples. Quantitative studies, on the other hand, include a part of relevant variables into their analysis with the concern of being parsimonious. Even though a far-reaching survey was accomplished to measure most of the factors, in terms of pathway diversity, it still falls short of being complete. Rather than the impacts of combinations of variables, the impact of individual effects is under consideration. Incompleteness could proceed from difficulty in measuring abstract variables as well. Therefore, a special tool is required to dissociate, and weight interwoven interactions formed by a large set of elements.

Various advances of FCMs were mentioned in the literature that could unravel the complexity of the HFW system and remedy the limitations of the aforementioned methods. First, with FCMs it is possible to model an HFW system composed of a larger number of elements as a whole. Ozesmi and Ozesmi (2004), who proposed a multi-step fuzzy cognitive mapping approach to model ecological problems, developed FCM for the case of the Uluabat Lake ecosystem (Ozesmi & Ozesmi, 2003) composed of 253 variables and 1173 relations. Ulengin et al. (2018) investigated the dimensions of the transportation sector related to climate change and identified 74 variables and 1214 relations that constitute the final FCM.

These numbers were highlighted to infer the extent of how many variables an FCM could be formed, not to indicate that a large number of variables is a prerequisite to constructing an FCM. On the contrary, FCMs can be made for almost any problem (Ozesmi & Ozesmi, 2004), and the number of variables is dependent only on the problem investigated. For instance, Giabbanelli et al. (2012) constructed an FCM of obesity problem with only 15 psychosocial determinants. In short, FCM allows handling a problem as a whole even if its contributing causes are in great number. So, the first motivation behind using the FCM approach is flexibility in representation as it facilitates including more concepts (van Vliet et al., 2010). In addition, the initial representation of the system can be continuously consummated with the addition of new factors and relationships (Jetter & Kok, 2014; Mei et al., 2014). In this respect, as well, the flexibility of the approach manifests itself.

The second motivation behind using the FCM approach is the pairwise evaluation of causal relations that enables researchers to cope with a complex network including loops and feedbacks (Alizadeh et al., 2017). Pairwise assessment of relationships between system elements allows considering all possible routes to a dependent variable rather than focusing on individual causal relations with it. Consequently, it is possible to represent the diverse effect of a single concept resultant from its following diverse pathways. Moreover, as the main scrutiny is to eliminate the gaps within the series of relationships leading to the dependent variable, the potential of distant elements is also taken into consideration.

The third motivation is that it is a tool that enables the researcher to deal with linguistic ambiguities (Alizadeh et al., 2017). Rather than concepts, the relationship strength is quantified that enables the verbal description of concepts whose quantification is hard (Jetter & Kok, 2014). As it utilizes expert's knowledge, FCMs allow a flexible description of system design (Mei et al., 2014). FCMs allow using natural language reflecting perceptions or beliefs and characterized by uncertain and vague information. Natural language is utilized as how it is formulated by experts or stakeholders (Nair et al., 2019).

Forth, it is possible to build collective FCMs based on data drawn from multiple sources. By doing so, views of different experts or stakeholders can be incorporated under one FCM which in the end presents a rich body of knowledge. Augmentation can be done by both mathematically mixing individual FCMs or encouraging experts to work in groups and reach a consensus on the elements, relationships, and weights of the system (Alizadeh et al., 2017; Papageorgiou & Salmeron, 2013). Thus, the FCM approach can resolute the problem of contradictory views regarding the system elements.

Fifth, through simulation analysis, FCMs become an advantageous tool to compare the system response to different scenarios (Ulengin et al., 2018). FCMs can be used for several purposes, and prediction is the one among others: explanatory, reflective, and strategic (Papageorgiou & Salmeron, 2013). Jetter and Kok (2014) highlighted that existing studies engage in FCM to improve mostly scenario planning

as a specific future study method. Uncertain future states that cannot be eliminated through information gathering can be simulated via FCM by building internally consistent scenarios. In the case of the HFW system, a great number of drivers have resulted in the desire to fight against each of them with a long list of proposed solutions. Facilitating scenario analysis, an FCM, in this regard, would be useful to compare the system reaction to different scenarios originating from these solutions.

The final motivation is that both the application and comprehensibility of FCMs are simple and straightforward (Mei et al., 2014). FCMs have taken the credit for their being easy to use, requiring relatively low computational time, and producing understandable end results for even non-technical audiences (van Vliet et al., 2010).

3.3 Three-Staged Methodology

In the current study three-staged methodology is used. The first stage was the identification of concepts and causal relationships that constitute the HFW system. The second stage was the construction of FCM by assessing causal relationships between concepts identified in the first stage. In the third stage, created FCM was utilized as a unit of analysis to simulate several scenarios inferred from mostly proposed HFW reduction solutions.

3.3.1 Identification of System Concepts and Causal Relationships

Identification of system concepts is the first stage to construct an FCM. In previous parts, while describing the method, it was highlighted that FCM is a graphical demonstration of how a system is perceived by human beings. So, this demonstration should be derived from the accumulated knowledge of human experts of the system who know its operation and behavior in different circumstances (Groumpos, 2010).

In the literature, three methods were proposed for knowledge elicitation. The first option (modeler is the expert) can be used for situations in which the researcher is also knowledgeable enough to be the expert at the same time. This approach, on the other hand, is unsuitable when it is necessary to capture the views of diverse groups.

The second option is surveying the experts in the form of questionnaires, interviews, or group discussions to capture in-depth knowledge (Jetter & Kok, 2014). Most of the FCM studies carried in the past decade utilized primary data obtained from interviews and workshops with experts (Alizadeh et al., 2017). As the third option, the researcher can analyze secondary data, written documents such as publications, reports, online discussions, and newspaper articles to identify system concepts (Jetter & Kok, 2014). Recently, content analysis of secondary data has been drawing the researcher's attention (Alizadeh et al., 2017). Furthermore, a combined approach that exploits the advantages of different methods can be applied. Ulengin et al. (2018) built a list of system variables based on both content analysis and experts' opinions.

Technical experts, academicians, people working for NGOs, or people from policy advisory groups, supposed to be knowledgeable in a domain, are commonly asked for their opinion to identify the concepts and interactions of this domain. For the HFW system, however, in their everyday life performing the food-related household practices, consumers are the main source of accumulated experience and knowledge from which all possible causal relationships could be disclosed. On the other hand, the majority of HFW reduction programs were built on expert opinion. According to Kim et al. (2019), to stimulate change, the consumer perspective should be used as a base while planning campaigns. For example, in a study conducting focus group studies with food packaging experts, it is realized that during food waste discussions they tend to mention their own household experiences as consumers instead of their professional opinion (Pearson & Perera, 2018). Therefore, within the scope of this study, consumers were conferred as the experts of the HFW system.

However, rather than going forward with the second option (surveying the consumers in the form of interviews), secondary data analysis was found to be more opportune and promising. Affluent empirical studies providing an in-depth analysis of consumer food waste behavior in the literature, compose a fruitful source for information retrieval without any limitation stemming from sampling or cultural boundaries. On the other hand, this affluence brought heterogeneity that makes the formation of a valid and reliable concept list challenging. At this point, the opinion of non-consumer (professional) experts was needed.

Therefore, a combined method was preferred for the current study as well. Identification of system concepts and causal relationships was based primarily on content analysis of published academic articles. Experts' opinion was utilized to ensure validity and reliability by following the steps of the guideline proposed to capture causal relationships for secondary sources (Alizadeh et al., 2017). One of the experts is a professor of supply chain analytics, logistics, procurement, and supply chain management at a well-known university in the UK. She has publications regarding drivers of food waste including aspects related to consumer behavior and food waste minimization. The second expert is working for the Turkey Ministry of Agriculture and Forestry as project coordinator for the national "Save Your Food Campaign (Gıdanı Koru)" to reduce food losses and waste in Turkey. The third expert is a food waste and loss consultant at Food and Agricultural Organization (FAO), Italy.

The coding manual, composed by Wrightson (1976) to determine the rules for building cognitive maps from documentary materials, was referred to conduct content analysis. The main principle of the coding protocol is to code each sentence, phrase, or paragraph stating a causal relation between two concepts. Causing concept, linkage, and effected concept are elements that structure the content as a causal relation. These structural elements, on the other hand, are not always aligned in this order or not always explicitly stated in a phrase. Even though a statement does not convey a grammatical and structural sense of causality, it may imply the causal relationship, therefore, should be coded. In other respects, the coder should prevent spurious implications. It is a danger that can emerge as the coder become familiar with the causal relationships that s/he has seen before. The rule of thumb proposed by Wrightson to cope with this danger is "*denotation rather than interpretation*" (1976: p. 293, 295). Assertions should not be driven by connecting two paragraphs or combining more than a few sentences (Wrightson, 1976).

Software package QSR NVivo 10 was utilized, as it enables performing qualitative assessment by coding relevant keywords (Leech & Onwuegbuzie, 2011) which will be used to drive concept variables as well as specifying underlying patterns in textual data.

An initial list of concepts (codebook) was prepared after an unsystematic literature review. This preliminary review was also useful while determining the criteria applied for article sampling. This initial codebook had been continuously revised as content analysis and discussions with experts continued. Codebook (see Appendix A) went through 4 revisions until it was finalized. Each time a revision was made, all contents coded under the revised concept and its relationships were reviewed and re-coded following the new formation. In this respect, the formation of the codebook was a highly iterative as well as a fulfilling process.

One of the considerations while defining the concepts was abiding by the original language used in documents as advised by Wrightson (1976). Second, to be able to define causality between concepts, they were qualified as variables that can decrease and increase. As it is mentioned before, for validity and reliability, Alizadeh and Jetter (2017) proposed some steps that were followed in collaboration with experts in the current study as well. These steps included consolidation of identical concepts, adoption of consistent terminologies for conceptually similar concepts, and tuning the granularity for concepts and sub-concepts (Alizadeh et al., 2017).

To specify the articles that were going to be coded, purposive sampling was performed. From the list including only scholarly reviewed articles derived from Web of Science by searching the keyword “Household Food Waste”, articles were selected or excluded according to the following inclusion or exclusion criteria.

Inclusion criteria:

- Aim of the study should be the exploration of HFW drivers.
- Discussion should be developed around food-related household practices even though social practice theory was not explicitly mentioned as the primary framework of the study.
- Providing the richest content, studies, utilizing qualitative methods such as ethnography, interviewing, and observation were preferred to be able to gather maximum information per article. In addition, they represented better the perception of consumers with the natural language used.
- Literature review studies were included to compensate for the possible data loss stemming from the exclusion of a relevant article.

- To capture the cultural differences, the categorization of studies in terms of the context was taken into consideration. Diversity under this category was aimed to be obtained, and articles were selected accordingly.

Exclusion criteria:

- Studies utilizing quantitative methods such as questionnaires were excluded since they were limited in terms of variable and interaction diversity. Those studies, on the other hand, were addressed to fill the relationship gaps in the adjacency matrix.
- Studies dealing with waste management alternatives such as separate waste collection and biological recovery as well as with measurement of the waste amount or the burden of food waste on the environment were excluded.

Articles selected following these criteria were listed in Appendix B.

Even though the saturation point had been reached in the eighth article, coding continued until the total number of articles reached 17 to obtain context diversity and to capture more relationships. Figure 7. demonstrates the accumulation of concepts by the increase in articles.

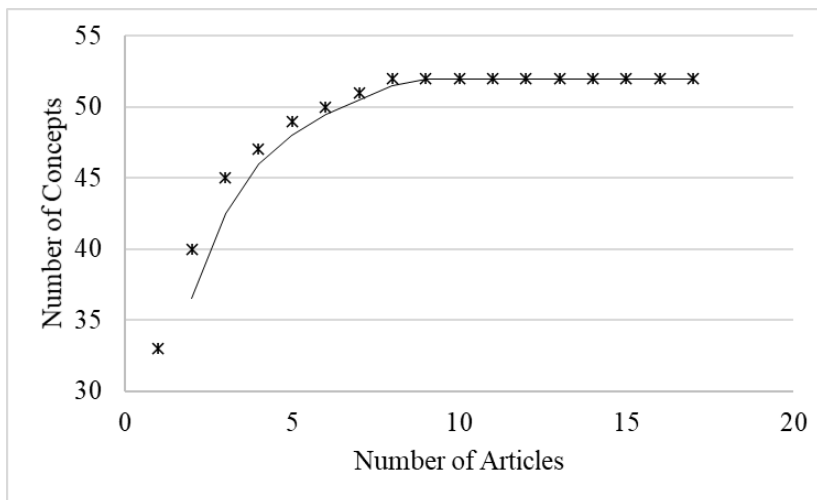


Figure 7 Accumulation Curve of System Concepts

As a result of content analysis and discussions with experts, some of the least mentioned concepts were excluded due to their weak impact within the system. The final list of concepts and their detailed explanations were presented in Chapter 4.

Together with concepts, causal relationships between them were identified as well. At this stage, one further step proposed by Alizadeh and Jetter (2017) for the sake of improving research results was followed. They highlighted a peril of possible gaps in the resulting model stemming from nonaffiliated groups of closely connected concepts. Reasons behind the peril could be referring same body of literature. Therefore, having determined the list of system concepts, further investigation of quantitative studies was done to explore new interactions that could fulfill the gaps within the network. From the initial list of articles derived from Web of Science, 34 quantitative studies (see Appendix C) were examined and coded for causal relationships between concepts.

To sum up, data gathered from the content analysis of 17 qualitative articles and expert opinion used to comprise the list of most prevalent system concepts. Data gathered from the analysis of a total of 51 articles (both qualitative and quantitative) was used to identify causal relationships between these concepts. As it can be seen in Figure 8., the investigation continued with 18 articles even after the saturation point for the number of relationships had been reached at the 34th article.

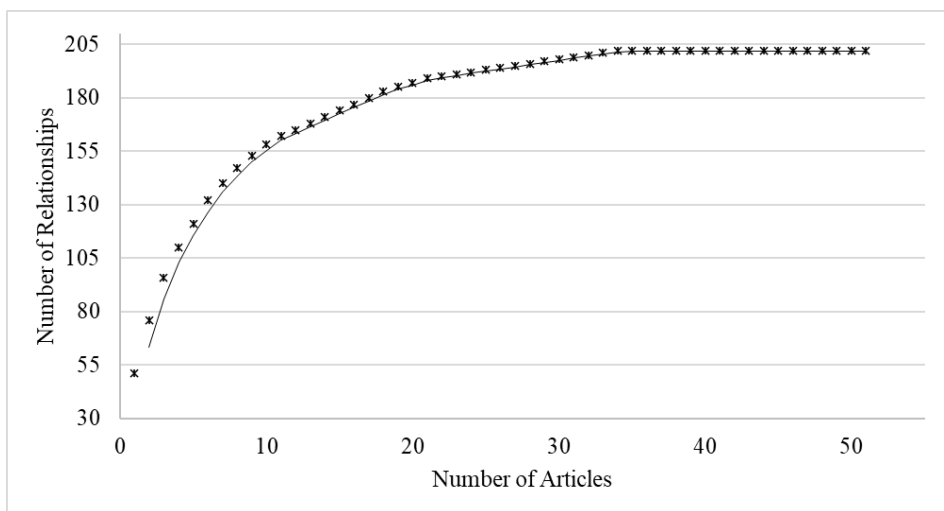


Figure 8 Accumulation curve of causal relationships

3.3.2 Construction of FCM and Structural Analysis

As a result of document analysis carried out in the first stage, quantitative data in the form of article numbers for each causal relation was obtained. To construct an FCM, this data had to be transformed to the form of relationship strength ranged between $[-1, 1]$. However, between some concepts, conflicting relationships had been coded which made this transformation complicated. Inspiring from the method proposed for adding individual maps together (Ozesmi & Ozesmi, 2004), a rule was defined for the computation of strengths. Ozesmi and Ozesmi (2004) emphasized that an augmented map gathered by adding many different maps would represent the system better. While agreement about a relationship direction (positive, negative, or neutral) tightens its strength, disagreement weakens. So, to compute compound values for augmented maps, negative-positive-neutral calculus was suggested to be used (Zhang & Chen, 1988).

Departing from this point of view, first, it was supposed that each article was an expert producing an individual cognitive map. Then, the following steps were carried out to form one FCM from these individual cognitive maps.

- All relationships were listed with the number of articles they were inferred.
 - Conflicting relationships were consolidated by adjusting the number of articles. The number of articles coded for the weakest relationship was extracted from the number of articles coded for the most powerful relationship.
 - Then, the number of articles was normalized to the range of $[-1, 1]$.
- According to the results of content analysis, a positive (+) causal relationship between concept *A12* and concept *I* was coded in 25 articles which is the highest frequency. So, this relationship is the most powerful one within the whole system and attained with the highest value in the range, 1. So, the strength of a relationship coded in one article corresponded to 0.04, and all adjusted article numbers were normalized accordingly.

To illustrate, Table 4. shows relationships of concept *A1* only as a causing concept.

Table 4 A part of causal relationship list

Concept	Influence	# of Articles Coded		Strength of Influence
A1 →	A2 (+)	8	7	0.28
	A2 (NR)	1		
	A10 (+)	1	-	0.04
	A12 (+)	1	0	0
	A12 (-)	1		
	A12 (NR)	1		
	D3 (+)	1	-	0.04
	G1 (-)	1	-	- 0.04
	I (+)	12	2	0.08
	I (NR)	7		
	I (-)	3		

From this table, it can be interpreted that:

- Each of the following relationships was coded in 1 article: *A1* positively affects *A10* and *D3*, and negatively affects *G1*. Since any counterargument had been detected, adjustment of article number was not required. The strength of these three relationships was computed by multiplying the article number by 0.04. The resulting relationship strengths will be respectively 0.04, 0.04, and -0.04.
- It was coded in 8 articles that *A1* positively affects *A2*. One article, however, confirmed no relationship (NR) between them. Since the first account was more powerful than the second account, in the adjacency matrix positive relationship remained. Contradictory accounts, on the other hand, decreased the strength of this relationship. The number of articles was adjusted to 7 ($8-1=7$). Then, the resulting strength of the relationship would be 0.28 (7×0.04).
- Regarding how *A1* affects *A2*, there were three different accounts: positively affects, negatively affects, and does not affect. Each relationship was coded in 1 article. Positive and negative relationships neutralized each other, and any relationship was defined for the corresponding cell in the adjacency matrix.

- Similarly, three different relationships were proposed between *A1* and *I*. The most powerful one, with 12 articles, was that *A1* positively affects *I*. Second most powerful one, with 7 articles, was that *A1* does not affect *I*. The least powerful one, with 3 articles, was that *A1* negatively affects *I*. The most powerful relationship, a positive one, was acknowledged but with an adjusted article number, 2 ($12-7-3=2$). Then, the strength of the relationship would be 0.08 (2×0.04).

After the computation of influence strength for all acknowledged relationships, $n \times n$ adjacency matrix where n represents the number of concepts was prepared. By using this matrix, the final FCM model was constructed on FCMapper Software (Bachhofer & Wildenberg, n.d.). Once the FCM was constructed, several structural analyses were conducted to indicate characteristic features of the HFW drivers system and its concept variables. Those indices were introduced in Chapter 4.

3.3.3 Scenario Analysis

Rather than being a standalone method, FCMs are the main method for scenario generation (Jetter & Kok, 2014: p. 55). The FCM constructed at the previous stage of the study was utilized as the unit of analysis of scenario analysis to cover alternative future states. Various scenarios were created and compared within a consistent demonstration of the HFW system not to forecast those future states but to gain insights into their long-term impacts (Ulengin et al., 2018).

Before the investigation of system responses to different scenarios, first, each concept was activated individually to attain a ranking by their HFW decreasing power within the system. Concepts were attained with 1 (0) if an increase (a decrease) in its value is expected to mitigate a decrease in the value of HFW. Then, an iterative calculation of the system variables' values was conducted for each activation on FCMapper software. Values obtained as a result of activation are meaningful as long as they are compared with the ones calculated initially, without any activation. So, the computed value of HFW after each activation was subtracted from the initial steady-state value to obtain how much decrease each concept could achieve.

Another purpose of individual activations was to figure out the dominant impact of the concepts that can both increase and decrease the value of HFW by following different pathways. Since the direction of change necessary to reduce HFW could not be estimated before running the system, these concepts were attained both 0 and 1. Only the one that leads to a decrease in HFW value was presented in Chapter 4 with the results of all individual activations.

Afterward, scenarios were generated regarding HFW reduction solutions proposed in the literature. For each scenario, concepts that are highly possible to be activated were listed. Affecting multiple elements of the system, a solution can have both increasing and decreasing effects on HFW. Therefore, while determining activated concepts, both promises and rebound effects of a scenario were taken into consideration. Similarly, activated concepts were attained with 0 or 1 following scenario specifications, and FCM was run to reach an equilibrium state. Change in the value of HFW was calculated for each scenario which was the base data for the discussion of solution effectiveness. Results of scenario analysis together with detailed scenario specifications were introduced in Chapter 4.

CHAPTER 4: FINDINGS

This chapter will introduce the main findings of the study under the following themes: HFW system concepts and causal relationships with specifications, FCM constructed with these concepts and structural indices, and results of scenario analysis carried out with HFW reduction solutions proposed in the literature.

4.1 HFW System Concepts and Causal Relationships

The first stage of the three-staged methodology was the identification of system concepts and causal relationships by conducting a content analysis and applying for an expert opinion. A codebook, composed of 52 variables, was used. As a result of the content analysis of qualitative articles (see Appendix B), data in the form of coding frequency was obtained for each concept. By referring to this data as well as discussing with experts, some of the least mentioned concepts were excluded, and the number of variables was reduced to 35 including independent variable HFW. Table 5 shows the list of main concepts causing HFW. They were classified under 8 categories and labeled accordingly. *A2* (Excessive Purchasing) and *A12* (Fail to Consume) were the most coded practices with 16 articles out of 17. *A1* (Poor Shopping and Meal Planning) and *A9* (Cooking and Serving too much) followed them with 15 articles. Under the category of attitudes and preferences *B1* (Preference for Fresh and Variety) was the most coded one with 14 articles. *E1* (The rhythms of everyday life) was the most coded socio-temporal factor prevalent in HFW generation with 14 articles. *C1* (Good Provider Identity) and *C2* (Food Safety and Health Concern) turned out to be the most coded concerns with 13 articles.

Table 5 List of System Concepts

Category	Main Concepts	# of Articles Coded ²
A. Food Related Household Practices	A1. Poor Shopping and Meal Planning	15
	A2. Excessive Purchasing	16
	A3. Shopping Frequency	9
	A4. Stockpiling	12
	A5. Lost/Forgotten/Ignored food items	8
	A6. Poor Storage Practices	7
	A7. Failure to Extend Lifetime of Food	6
	A8. Using Freezer	9
	A9. Cooking and Serving too much	15
	A10. Leftover Generation	13
	A11. Cooking Style	7
	A12. Fail to Consume	16
	A13. Reluctance to use own senses	10
B. Attitudes and Preferences	B1. Preference for Fresh and Variety	14
	B2. Value/Appreciation of Food	11
	B3. Feeling of Guilt	10
	B4. Suboptimality Perception	6
C. Concerns	C1. Good Provider Identity	13
	C2. Food Safety and Health Concerns	13
	C3. Economic Concerns	10
	C4. Environmental Concerns	4
D. Infrastructure of Provisioning	D1. Lack of Smaller Package Sizes	13
	D2. Low Food Prices	7
	D3. The Attraction of Special Offers	6
	D4. The Magnitude of the Food Store	5
	D5. Accessibility/Physical Proximity of Store	5
E. Socio -Temporal Context	E1. The Rhythms of Everyday Life	14
	E2. Past Bad Experiences	7
	E3. Effort Devoted for Food Practices	6
	E4. The Detachment of Food Production and Consumption	4
F. Package and Food Properties	F1. Temporality/Perishability of Food	10
	F2. Confusing Date Label	8
G. Knowledge and Awareness	G1. Lack of Knowledge/Skills/Awareness	12
H. Domestic Material Conditions	H1. Limited Technological Advancements	5
I. Household Food Waste		17

² Concepts and frequencies are derived from the content analysis of 17 articles (see Appendix B)

The following sections provide detailed explanations of system concepts, introduce the most prevalent causal relationships, and contradictory accounts.

4.1.1 Food Related Household Practices (A)

Planning practices can be described as the commencing point of the behavioral system of successive and interacting household food-related practices. Under this category, practices performed for both shopping and meal planning are incorporated. The most disclosed ways of planning are meal planning and accordingly identifying needed food items, checking inventories (in other words having an overview or awareness of current food stock), and making a shopping list before going on a shopping trip. These practices are proposed as necessary strategies to reduce HFW, therefore, their absence is a driving factor of HFW generation. For this reason, **poor shopping, and meal planning (A1)** identified as one of the main concepts of the HFW drivers system. As a result of content analysis, it is the third most mentioned construct prevalent in the discussion of HFW.

The most powerful antecedent of poor planning is time availability. Within a busy life, due to lack of leisure time, consumers pass over to check for inventories and to prepare a list (Pellegrini et al., 2019; Schanes et al., 2018). When we compare planning routines and other concepts of the system, they are one of the most controversial elements as well. Opposite stances are expressed in the literature. One side stands up for the fact that food waste behaviors are directly related to planning routines (Farr-Wharton et al., 2014; Janssens et al., 2019; Mattila et al., 2019; Stefan et al., 2013 and others). The other side, conversely, asserts that there is no relation between poor planning and the amount of food wasted (Bravi et al., 2020; Elimelech et al., 2019; Giordano, Alboni, & Falasconi, 2019; Stancu et al., 2016 and others). Some scholars even propound that strict and long-term planning may restrict the flexibility of consumers and may lead to more HFW in the case of time constraints and plan disruptions (Dobernig & Schanes, 2019; Urrutia et al., 2019).

On the contrary, there is an apparent consensus about the relationship between poor planning and excessive purchasing. Planning routines can mitigate overbuying by reducing the tendency to buy unplanned items and big packs and thus reduce

consumer food waste (Dobernig & Schanes, 2019; Farr-Wharton et al., 2014; Stancu et al., 2016; Stefan et al., 2013). Being unaware of their current food stock or not having a shopping list, consumers may make uninformed choices and purchase items they already have (Farr-Wharton et al., 2014; Wansink, 2018). Moreover, when consumers go shopping unplanned, they become more susceptible to an external stimulus such as promotions and discounts that cause impulse purchase of unnecessary items (Farr-Wharton et al., 2014; Mattila et al., 2019).

Among shopping practices, **excessive purchasing (A2)** is the most substantial driver of HFW. Various situations are included under this practice, impulse buying (purchasing beyond what is needed or planned) purchasing both proper (healthy) and backup items, purchasing what already exists at home, and purchasing in bulk or big packs. According to content analysis, together with the failure to consume what is the stock in time, it is the most mentioned practice associated with the amount of HFW.

Consumers overbuy food products due to promotional attractions in store such as buy-one-get-one-free (BOGOF) and discounts (Farr-Wharton et al., 2014; Graham-Rowe et al., 2015; Porpino et al., 2015), unavailability of smaller packages sizes, poor planning, good provider identity/concern to provide abundance and economic concerns. As it is evident through the results of various quantitative analyses (Bravi et al., 2020; Falasconi et al., 2019; Janssens et al., 2019; Parizeau et al., 2015; van Dooren et al., 2019 and others), excessive purchasing is the second most significant direct driver of HFW. Furthermore, excessive purchasing induces subsequent food handling practices that could lead to HFW such as stockpiling, failure to consume what is in the stock, and cooking and serving too much. Its strong relationships with other concepts within the HFW drivers system put excessive purchasing in a position that should be targeted by interventions and initiatives aiming to reduce HFW.

Another shopping practice that is much discussed as one of the influencing factors of HFW is **shopping frequency (A3)**. The general view is that consumers who are shopping frequently (2 and more times a week), waste lesser compared to those who are shopping less frequently (Once in a week or 7 to 10 days) (Falasconi et al., 2019; Fanelli, 2019; Jörisen et al., 2015; Lee, 2018). Giordano et al. (2019) found that HFW levels were almost doubling for the families who are shopping once a

month or every two weeks. When consumers shop frequently, they rarely stockpile and can consume what is in the stock in time (Sirola et al., 2019). Jörissen et al. (2015) conducted a comparative study and found that in Germany there is a similar relationship. In Italy, on the other hand, HFW increases as shopping frequency increases. Among all the elements of the system, shopping frequency is influenced most by the proximity of food retailers (Dobernig & Schanes, 2019; Lanfranchi et al., 2016; Lee, 2018; Sosna et al., 2019). Lack of food stores within walking distance lowers shopping frequency (Urrutia et al., 2019).

Under storing practices, some improper practices performed by consumers while they are keeping purchased or leftover food items in whatever place they utilize as storage such as fridge or pantry. Discussion regarding how the way of food handling throughout its storage life influences HFW amount, however, revolve mostly around the ineffective use of fridge. The role of the fridge as a non-human agent in HFW generation is another element of the system that is going to be discussed in domestic material conditions.

Among the malpractices concerning food storage, **stockpiling (A4)** is the one that is mostly referred to as a driver of HFW (Aschemann-Witzel et al., 2015; Setti et al., 2016). Dobernig and Schanes (2019) especially emphasize spoilage as a consequence of preferring to store food at home rather than purchasing fresh. Stockpiling – stocking too much food (overstocking) – is due to mainly excessive purchasing (Farr-Wharton et al., 2014; Porpino et al., 2015; Schanes et al., 2018). Abundant food may also be stocked due to a good provider identity developed as cultural norms. For instance, Porpino et al. (2015) revealed that caregivers from the low-income segment in Brazil need overstocking to feel secure or to signify status. Consumers may also take refuge behind the risks of unanticipated occasions and use stockpiling as a strategy to save time (Porpino et al., 2015; Schanes et al., 2018).

As a natural consequence of stockpiling, **lost/forgotten/ignored food items (A5)** are the next most declared storage practice. Wansink (2018) adverted a study that provided evidence that food, especially if it is shelf-stable, was the most common cabinet castaway. These products might be bought for a never happened special occasion and kept in an invisible place until it is expired or even after its expiration

date. More than half of the participants of this study stated that they would throw these forgotten items out without any hesitation. Alongside the shelf-stable food, leftovers are commonly lost, forgotten, or consciously ignored as they are wrapped or repacked and placed behind the refrigerator where it is not plausible to notice their existence and consume in time (Hebrok & Heidenstrom, 2019; Porpino et al., 2016; Schanes et al., 2018).

Some good storage practices are prescribed such as the systematic organization of fridge instead of placing items randomly, appropriate use of technological advancement of the fridge (ex: setting optimal temperature, using optimal places for a different type of food, etc.), using special containers for the storage of leftovers (ex: cheese covers, glass containers, transparent plastic boxes, etc.) and sorting out and cleaning the fridge regularly. Abeyance of these practices in a household expressed as **poor storage practices (A6)** in this study, maybe eventuated in throwing away expired or spoiled food away (Aschemann-Witzel et al., 2015; Dobernig & Schanes, 2019; Farr-Wharton et al., 2014; Hebrok & Heidenstrom, 2019; Porpino et al., 2015; Schanes et al., 2018; Wikstrom et al., 2019). Poor storage practices constrict the time window within which food items could be consumed and not be wasted. On the contrary, it is possible to enlarge this window with good storage practices to avoid HFW to an extent. In other words, **failure to extend the lifetime of food (A7)** stored in households is another storage practice prevalent in HFW generation. **Using a freezer (A8)** is segregated from good storage practices as an important strategy to extend storage life. Freezing the surplus or leftover, however, has a rebound effect. Items in the freezer could be forgotten and lose their appeal for consumption.

Among the food preparation and serving practices, **cooking, and serving too much (A9)** is the most significant one attributed to HFW. In addition, it is the fourth most mentioned concept. Cultural norms such as hospitality (Baig et al., 2019), wish to be a good food provider (Aschemann-Witzel et al., 2015), food seen as wealth (Porpino et al., 2015) are the greatest motivation behind cooking and serving in huge quantities. The second most significant reason why food is prepared too much is practicality (Porpino et al., 2015). Especially, working mothers (Porpino et al., 2016) cook too much to have a proper meal for several sittings (Evans, 2011; Farr-Wharton

et al., 2014) as well as to save time (Mattila et al., 2019). For those families, generating leftovers is a strategy to cope with a busy lifestyle.

However, **leftover generation (A10)** came forward as the tenth most potential driver of HFW. Leftovers do not transform into waste as long as they could be managed properly and consumed in time. The opportunity of leftover consumption, on the other hand, is precluded by many other elements of the system such as household members' preference for fresh and variety in their diet, unforeseen events, and food safety and health concerns. For this reason, leftover generation is accepted as a prevalent factor that stimulates wasting food. In this study, the leftover concept constitutes cooked meals as well as partially used ingredients. Too large packages were found to be the origin of leftover ingredients (Sirola et al., 2019; Wikstrom et al., 2019). **Cooking Style (A11)**, at this point, swings the balance between creating a use occasion for leftovers or throwing them away. Consumers who abide by "tried and tested recipe" miscarry to use up what is in the fridge (Evans, 2011, 2012). While pursuing such a style is treated as a cause of food being wasted, cooking with what is in the fridge – food waste cooking – is found to be an effective strategy to reduce HFW (Schanes et al., 2018). The strongest obstacle behind adopting a food waste cooking style is the lack of knowledge and skills to utilize leftovers creatively (Evans, 2012; Farr-Wharton et al., 2014; Schanes et al., 2018).

Food will not turn into waste as long as it is consumed. Due to this fact, rather than how food is eaten, whether it could be consumed or not comes forth as a key element of the HFW drivers system. Sharing its place with excessive purchasing, **failure to consume what is in the fridge in time (A12)** is the most mentioned cause of HFW. This concept represents the amount of food that remains uneaten in consumers' homes (Dobernig & Schanes, 2019) and mostly constitutes uneaten leftovers due to a preference for freshness. Leftovers are thrown away since household members simply do not like eating the same meal and want variety in their diet (Baig et al., 2019; Evans, 2012; Farr-Wharton et al., 2014; Urrutia et al., 2019; Wansink, 2018). Beyond preferences, food might remain uneaten due to the unpredictability of the natural flow of life (Evans, 2011). Unforeseen events or 'spur-of-the-moment' situations (Farr-Wharton et al., 2014) such as unexpected dinner invitations or spontaneously spending time with friends creates a discrepancy between

what is planned to be eaten and what is eaten (Schanes et al., 2018). Alongside the rhythm of everyday life, the temporality of food puts another strain on the consumption of food in time (Evans, 2012).

Within the mismatch between these two notions, even when an occasion for consumption could finally be created, food might have been so close to or has newly passed its expiry date. At this juncture, how the edibility of food is assessed has crucial importance in saving food from being wasted. In this decisive moment, consumers may follow two routes: trust their senses (Farr-Wharton et al., 2014) or rely on date labels (Evans, 2011). Consumers would miss the opportunity of saving food that is expired but still edible when they rely on date labels. Therefore, **reluctance to use own senses (A13)** turns out to be an influencing factor of HFW. Parizeau et al. (2015) found that participants who used mostly smell or appearance as an indicator but relied on best before dates and number of days in the fridge to a lesser extent wasted less food. Food safety and health concern is the primary antecedent of this element followed by a lack of knowledge and competence. Since edibility assessment is generally performed shortly before consumption, this practice is presented under consumption practices.

4.1.2 Attitudes and Preferences (B)

Preference for fresh and variety (B1) is the most mentioned driver of HFW under the category of attitudes and preferences. Preference for freshness as a top cause of wasting food (Porpino et al., 2016) means rejection of repetition (Urrutia et al., 2019) and leftovers in the meanwhile. Consumers may find eating the same meal repeatedly boring and create an aversion towards eating leftovers (Schanes et al., 2018). The feeling of disgust may even accompany aversion to leftovers specially to reheating them (Aschemann-Witzel et al., 2015; Schanes et al., 2018). Having concerns to be a good provider promotes negative attitudes towards consuming leftovers via providing multiple choices and allowing pickiness (Aschemann-Witzel et al., 2015; Porpino et al., 2016). Even the families, who do not such an aversion and prepare large meals on purpose to eat in several sittings, may lose their desire to consume leftovers. People go for what they desire at the moment rather than restraining themselves to eat what is in the fridge (Hebrok & Heidenstrom, 2019).

The value given to food, on the other hand, could prevent the loss of desire to consume leftovers (Farr-Wharton et al., 2014). As the perceived value of food, in other words, appreciation of food increases (Sirola et al., 2019), it becomes harder to waste it (Dobernig & Schanes, 2019). Therefore, **the value/appreciation of food (B2)** is the second attitudinal driver of HFW. Value could have various dimensions. When people perceive food as a gift rather than a product, they attribute a higher symbolic value to it and develop a strong attitude towards food waste avoidance (Aschemann-Witzel et al., 2015; Dobernig & Schanes, 2019). Monetary value is the most apparent dimension. Expensive foods, such as meat and fish, are less frequently wasted than cheaper foods, such as vegetables and bread (Hebrok & Heidenstrom, 2019). Utilization value is dependent on how much food is intact and new. When food is partially used, it loses its utilization value which means that leftovers are valued to a lesser extent (Hebrok & Heidenstrom, 2019). However, among all the dimensions mentioned, time value has the greatest influence on how much food is appreciated. According to the content analysis, the effort devoted to food practices is the key element that determines the value/appreciation of food. It is harder to waste homemade meals cooked from scratch compared to ready-to-eat alternatives or food eaten in a restaurant (Dobernig & Schanes, 2019; Hebrok & Heidenstrom, 2019). Self-grown and harvested food are less likely to be thrown away since the time and effort devoted to its production are embedded in its value (Ganglbauer et al., 2013).

The higher value attributed to food stirs the **feeling of guilt (B3)**, an intuitive feeling that wasting food is wrong (Aschemann-Witzel et al., 2015; Sirola et al., 2019). Throwing ‘good’ food or something valuable away is occupied with ‘worrying’, ‘feeling bad’, ‘feeling guilty’, or ‘feeling regret’ (Evans, 2011). This strong instinct that throwing food away is an inconvenient behavior (Porpino et al., 2015) was suggested to be a motivation to reduce wasteful behaviors (Abeliotis et al., 2016; Schanes et al., 2018) such as fail to consume what is in the stock in time. People who informed feeling guilt when wasting food would be more responsive to the occasions of consuming leftovers (Mattar et al., 2018). In other respects, consumers may not always cope with the feeling of guilt by performing waste-reducing practices. Due to avoidance-oriented behavior, negative feelings might even have a positive relationship with the amount of HFW. As consumers engage in

negative feelings more, they waste more (Russell et al., 2017). For instance, a food or a leftover is not directly disposed of even if its inedibility is sensed. To mitigate the feeling of guilt, it is left somewhere invisible in the fridge until the time when it will go off completely. ‘Maturation time’ and ‘procrastination’ are terms used for the practice of deferring unpleasant task of disposal (Blichfeldt et al., 2015; Evans, 2011; Porpino et al., 2016).

The final element of this category is related to attitude towards visual imperfections in food. Some consumers use appearance as a cue for quality and show little tolerance to deviations from common standards (Aschemann-Witzel et al., 2015; Evans, 2011; Schanes et al., 2018). Fruits that have an irregular shape, small and brown spots on the surface, or packaged food that is close to its expiration date are examples of suboptimal food. It is likely for a suboptimal food to be thrown away even if it is edible when the consumer has a negative attitude towards suboptimality. Consumer visceral understandings regarding suboptimal food are shaped by their past bad experience, upbringing memories, and lack of connection with the production of the food. Those who have more environmental concerns are more tolerant of suboptimal foods. Discussions mostly revolve around how **suboptimality perception (B4)** affects consumers’ decisions at the point of purchase. On the other hand, it could be a factor of HFW as well. With eye-tracking research, it is proven that the choice of apples with external and internal defects is low for point of both purchase and consumption.

4.1.3 Concerns (C)

Daily concerns may avert consumers to prioritize HFW avoidance even if their intentions are in the opposite direction. Among them, cultural aspects such as good mother identity, hospitality, and taste for abundance were argued mostly as important antecedents of wasteful practices (Aschemann-Witzel et al., 2015; Baig et al., 2019; Evans, 2011; Farr-Wharton et al., 2014; Graham-Rowe et al., 2015; Porpino et al., 2015; Porpino et al., 2016). Taking most of the responsibility of food-related practices in a household, women inherently use these practices as an instrument to show their love to their family. For the sake of satisfying the wishes of each family member, wasteful practices such as excessive purchasing (Evans, 2012), cooking too much, or

throwing leftovers away become unnoticeable (Aschemann-Witzel et al., 2015). Mothers fear not being perceived as offering abundance not just to family members but also to visitors (Hebrok & Heidenstrom, 2019). In cultures where hospitality has great importance, especially during special occasions such as festivals and weddings, food waste is not definitely under consideration but offering abundance is the only focus. That is why instead of a good mother identity, **the good provider identity (C1)** concept is used to cover hospitality as well.

Good provider identity is highly correlated with a taste for the abundance that is developed against being identified as poor (Porpino et al., 2016). With research conducted in Brazil with the low-income segment, it is found that providing plenty of food reflects good provider identity concern. This causality creates the most referred paradox in the literature regarding the drivers of HFW. Generally, it is asserted that the amount of HFW is positively correlated with economic conditions. With this study, on the other hand, it is revealed that 'poor' wastes even more than the 'rich' in order not to let their family to feel 'poor' (Porpino et al., 2015). Apart from offering food in abundance, offering proper food (Graham-Rowe et al., 2015) is the other concern mothers to fulfill their desire to be perceived as good providers (Evans, 2012). This aspect is incorporated in the scope of next most referred concern, food safety and health concerns.

Food safety and health concerns (C2) have two folds: concern to eat and provide proper food and concern regarding foodborne illnesses or food poisoning. Proper food constitutes fresh, healthy ingredients that are used to prepare cooked meals from scratch whilst incorporating a variety of flavors and ethnic cuisines (Evans, 2012). Efforts to eat as well as offer proper food to significant others could be a basis for consumers to perform wasteful practices. For instance, purchasing or cooking both proper alternatives and back-up items to prevent household members from going out to eat (perceived unhealthy) leads to excessive purchasing or cooking too much (Evans, 2012). Consumers make a trade-off between food safety and health risk avoidance and food waste avoidance (Aschemann-Witzel et al., 2015) especially when the edibility of food is vague. As food safety and health risk perception increases, distrust to own senses starts to take effect in the system while evaluating the edibility of a leftover or recently expired food product. Reluctance to use own

senses, then, leads to the early disposal of still edible food. If people assess the edibility with the fear of possible food risks, they throw away more (Parizeau et al., 2015). Furthermore, Baig et al. (2019) stated that people prefer not to eat leftovers since they perceive them as unhealthy. Schanes et al. (2018) underlined the fact that people waste less if their risk perception of consuming leftovers is low (Visschers et al., 2016). Similarly, Giordano et al. (2019) found that higher amounts of food waste belong to participants who ate healthily and interpreted the root cause as the preference for fresh.

Economic concern (C3) is the third most mentioned factor which could be both a motivation for HFW avoidance and a cause of wasteful practices. If HFW is perceived as a waste of money (Falasconi et al., 2019), HFW avoidance could take a place as a primary consideration via ‘good housekeeping’ (Aschemann-Witzel et al., 2015) or thriftiness (Sosna et al., 2019) within the kitchen. Intending to save money, consumers pay attention to reuse leftovers (Ellison & Lusk, 2018; Revilla & Salet, 2018). Consumers’ price sensitivity could reflect how much they are concerned about the economic consequences of their practices, especially while shopping. Amirudin and Gim (2019) found that consumers waste a larger amount of their food when they attached less importance to the price. It is also known that expensive food products such as meat products are less likely to be wasted. However, price orientation creates another path towards wasting food. Preference for larger packages or bulk purchases and attraction to special offers that lead to excessive purchasing are consequences of money-saving efforts (Dobernig & Schanes, 2019; Farr-Wharton et al., 2014; Porpino et al., 2015). Since larger packages offer a better deal, purchasing small-size alternatives is thought to be a practice against the notion of thriftiness (Urrutia et al., 2019). Excessive purchasing through purchasing larger amounts is the second most powerful driver of HFW. Therefore, the economic concern could have both positive and negative impacts on HFW.

As a multidimensional notion, thriftiness is feeling responsible just not for the financial cost of the waste but also for long-term environmental outcomes (Sosna et al., 2019). This brings us to another motivation for HFW avoidance, **environmental concern (C4)**. Conflicting results take place in the literature. One side presented that there is a negative relationship between environmental consciousness and the amount

of wasted food (Diaz-Ruiz et al., 2018; Elimelech et al., 2019; Jereme et al., 2016; Secondi et al., 2015). According to Jereme et al. (2016) consumers engage in food waste-avoiding practices as long as they are aware of the environmental impacts of food waste. Apart from its direct relationship with HFW, it has the potential to decrease HFW by mediating aspired practices. Consumers who are highly committed to environmental sustainability are more tolerant to consume suboptimal foods (Aschemann-Witzel et al., 2015; de Hooge et al., 2017). In addition, a strong correlation between environmental concern and negative attitude towards wasting food was shown (Melbye et al., 2017; Pellegrini et al., 2019). The other side, on the other hand, propounded that environmental concern is not an effective factor in HFW generation (Amirudin & Gim, 2019; Falasconi et al., 2019; Giordano, Alboni, & Falasconi, 2019). In addition to all these accounts, we may say that literature has achieved a consensus about a point. Even if the environmental concern is thought to be a component of HFW avoidance, its impact falls behind the impact of economic concern (Schanes et al., 2018).

4.1.4 Infrastructure of Provisioning (D)

Under this category, factors related to the food store environment are clustered. A common characteristic of all is their ability to govern shopping practices independently of consumers' attitudes, preferences, and concerns (Dobernig & Schanes, 2019). **Lack of smaller package sizes (D1)** is the most mentioned one (Aschemann-Witzel et al., 2015; Porpino et al., 2016; Schanes et al., 2018; Urrutia et al., 2019; Wansink, 2018; Wikstrom et al., 2019). Unlike individual preference of larger packages discussed in economic concern, the material infrastructure of provisioning supplied to consumers impels them to excessive purchasing (Evans, 2012). Too large packages were reported as a cause of HFW especially for consumers living alone (Evans, 2011; Graham-Rowe et al., 2015) since it is highly likely that they fail to consume excessively purchased ingredients. Sirola et al. (2019) adduced that small and single-unit package sizes usually in Japan enable consumers to keep the balance between the amount of what is purchased and the amount that is going to be eaten.

Low food prices (D2) are the second most mentioned driver of HFW under this category. Baig et al. (2019) associate the fact that Saudi Arabia ranked among the top 25 countries wasting food with economic affluence and welfare policies that made food affordable to the majority. Rather than its being a consequence of current macro-economic conditions, however, low food prices have a place within the HFW drivers system constituted by this study as a provision provided by retailers. The most explicate impact of low prices to HFW is through excessive purchasing. Apart from that, low food prices influence the value/appreciation of food (Hebrok & Heidenstrom, 2019) that is effective in multiple wasteful practices. As the value attached to food decreases due to low prices, little emphasis is given to the risk of wastage and subsequently, little effort is spent on HFW avoiding practices (Aschemann-Witzel et al., 2015). Even though its impact on HFW generation was manifested by various scholars, it is also accepted that increasing food prices means reducing the availability of food is not a feasible alternative to tackle with HFW (Aschemann-Witzel et al., 2015; Wansink, 2018). Nevertheless, it is retained within the system because its indirect role in HFW still become an issue when alternative infrastructures are suggested. For instance, one of the reasons of that local markets are proposed as a solution to HFW is higher prices offered by them (Dobernig & Schanes, 2019).

When a store environment is scrutinized as a food waste inducing agent, undoubtedly **attraction to special offers (D3)** would be the most distinct factor. Marketing has been blamed for conducting consumers towards excessive purchasing and stockpiling via promotional offers such as buy-one-get-one-free (BOGOF) (Aschemann-Witzel et al., 2015; Dobernig & Schanes, 2019; Farr-Wharton et al., 2014; Graham-Rowe et al., 2015; Porpino et al., 2015; Wansink, 2018). Even though many scholars met in the common ground that attraction to special offers indirectly impacts HFW through excessive purchasing, there is a lack of agreement regarding its direct relationship with HFW. There is empirical evidence showing that consumers who buy more special offers waste more food (Mattar et al., 2018; Mondejar-Jimenez et al., 2016). However, there are more that could not confirm a significant relationship between the two concepts (Falasconi et al., 2019; Fanelli, 2019; Giordano, Alboni, & Falasconi, 2019; Ponis et al., 2017). Jörisen et al. (2015) even identified a positive relationship and indicated that in households that are more interested in special offers

the amount of food waste is moderately lower. Therefore, only mediating relationships of attraction to special offers appear in the final fuzzy cognitive map.

The magnitude of the food store (D4) is the next prevalent factor discussed while exploring HFW drivers. With a systematic literature review study, Schanes et al. (2018) identified two major types of food store that are commonly preferred for food products: major large supermarket chains and smaller local stores or farmer markets (Farr-Wharton et al., 2014; Jörisen et al., 2015; Parizeau et al., 2015). Jörisen et al. (2015) found that households that solely shop from large supermarkets waste more food. On the other hand, consumers who regularly purchase local food spend more effort to restrict the frequency of vegetable wastes (Setti et al., 2016). Moreover, when food is supplied from farmer markets, consumers attach more symbolic value to it and develop a negative attitude towards wasting food (Dobernig & Schanes, 2019). However, shopping from farmer markets might have a rebound effect. Food bought from farmer markets would be generally perishable items consumption in time is likely to be failed (Farr-Wharton et al., 2014). Another route to HFW via the type of grocery store is through shopping frequency. Fanelli (2019) found that consumers who shop from smaller markets do frequent shopping, therefore, waste food to a lesser extent.

The magnitude of the food store, **accessibility / physical proximity of the store (D5)** is the next characteristic used to determine the impact of food store type on HFW. The most powerful relationship of the concept is with shopping frequency. As the physical proximity of the store increases, consumers able to shop more frequently (Dobernig & Schanes, 2019; Lanfranchi et al., 2016; Lee, 2018; Sosna et al., 2019; Urrutia et al., 2019). Dobernig and Schanes (2019) found dense food retail infrastructure critical in terms of regulating the imbalance between dynamic preferences for variety and what is needed which naturally leads to HFW through excessive purchasing. Urrutia et al. (2019) established a link between the mode of transportation used for shopping and excessive purchasing as another route to HFW. When food stores are inconvenient, going to shop with a car becomes a common practice which increases the tendency to stockpile and promotes excessive purchasing. Shopping from stores located within walking distance accompanies other

practices intended to reduce HFW: shopping frequently and purchasing only what is needed (Urrutia et al., 2019).

4.1.5 Socio-Temporal Context (*E*)

Alongside individual preferences, attitudes, concerns, and infrastructure of provisioning, food-related routines are shaped by how lives are lived (Evans, 2011: p. 45). The socio-temporal demands of today's everyday life (Evans, 2011) pose time constraints and bring unforeseen events along with that lead to disruption of desirable routines and orientation towards wasteful practices (Aschemann-Witzel et al., 2015; Dobernig & Schanes, 2019; Farr-Wharton et al., 2014; Porpino et al., 2015; Porpino et al., 2016; Schanes et al., 2018; Urrutia et al., 2019; Wansink, 2018). Socially unpredictable and temporally restricted nature of everyday life is subsumed under the concept of **the rhythm of everyday life (E1)** which is the fifth most mentioned factor within the HFW drivers system. Unexpected dinner invitations and spontaneously spending time with friends could be examples of socially unpredictable events come across in daily life (Schanes et al., 2018). Temporal constraint, simply lack of time to manage food properly, is driven by heavy workload (Jörissen et al., 2015). With a comparative study conducted in UK, Spain, and Italy, Bravi et al. (2020) found that too frenetic rhythm of everyday life contributes to HFW in all three countries. Hectic and spontaneous way of living leads to HFW through most fail to consume what is in the stock in time (Evans, 2011; Farr-Wharton et al., 2014; Hebrok & Heidenstrom, 2019; Porpino et al., 2015; Wansink, 2018), cooking too much (Mattila et al., 2019; Urrutia et al., 2019) and poor planning practices (Evans, 2011; Pellegrini et al., 2019; Schanes et al., 2018). Participants of the research conducted by Lee rated "*didn't have time to eat/cook it*" most as a cause of HFW (2018: p. 331).

As a follow-on consequence of hurriedness, the declining **effort devoted to food practices (E3)** is the next characteristic of contemporary lifestyles. Effort spent for specially food preparation could be reduced as consumers become contingent more upon eating out of their home, in restaurants, or eating ready to eat food. This inclination is proposed as an HFW driving factor. Consumers, who frequently eat out, produce more food waste (Bravi et al., 2020; Mallinson et al., 2016; Mattar et al., 2018; Parizeau et al., 2015; Ponis et al., 2017). On the other hand, some research

participants admitted that when a meal is prepared by themselves, it becomes harder to waste it. Time and effort spent in food preparation embedded into its value which in turn creates a negative attitude towards wasting it (Dobernig & Schanes, 2019; Hebrok & Heidenstrom, 2019; Porpino et al., 2016). This causality prevails while performing not just food preparation and eating practices but also shopping practice since it requires remarkable effort to be performed as well. Ilyuk (2018) indicated that the possibility of food items being wasted is higher when they are purchased via online grocery channels that is a more convenient way compared to traditional stores. Furthermore, Ganglbauer et al. (2013) discovered that people who grow and harvest their products become more aware of the effort devoted to the production and subsequently appreciative of the produce.

However, with the increasing urbanization, **detachment of food consumption and production (E4)** has emerged as a contributing factor of HFW. Secondi et al. (2015) observed that the amount of HFW produced by households in urban areas more likely exceeds the amount generated by households in rural areas. Consumers in rural areas show a higher disposition to perform desirable practices to reduce HFW such as consume all the food prepared (Mattar et al., 2018). In urban life detachment from food's origin and perceiving it just as an item purchased from supermarkets, contribute to HFW by adulterating its value. Experienced practitioners of agricultural food growing and harvesting value food more (Dobernig & Schanes, 2019), and the rural environment is an opportunity to gain this experience which creates a moral commitment (Sosna et al., 2019). Detachment affects the suboptimality perception as well. Having a lack of knowledge regarding how raw food is grown and harvested, consumers become less tolerant to variation in appearance and demand for perfection (Aschemann-Witzel et al., 2015).

Speaking of experience, not only the socio-temporal drawbacks of this period but also the historical background of consumers shapes their habits (Aschemann-Witzel et al., 2015). In the discussion of HFW drivers, historical background constitutes upbringing memories such as not being served with leftover in childhood and past bad experiences such as food poisoning or scarcities during war times. All together concept is defined as **past bad experiences (E2)** that play a role in both HFW production and HFW reduction. First, routes that contribute to HFW are

investigated. As a consequence of negative experiences with food in the past, consumers could become more sensitive to food safety and health risks and distrustful of food's edibility. This in turn leads to the early disposal of edible food (Farr-Wharton et al., 2014). Having food accessibility problems in the past, some families eradicate the poverty they lived by stockpiling. A fridge filled with plenty of food conveys a comforting duty for them (Porpino et al., 2016). On the other side, it is observed for some consumers, having experienced scarcity in the past, it is hard to waste food as they highly appreciate the food, they have today (Aschemann-Witzel et al., 2015; Farr-Wharton et al., 2014; Porpino et al., 2016).

4.1.6 Package and Food Properties (*F*)

Two package and food properties, interacting with prevailing individual preferences and concerns, partake in the HFW drivers system as important variables. The most frequently referred one is **the temporality/perishability of food (*F1*)**. Perishable foods have proven to be the most wasted ones (Fanelli, 2019; Lee, 2018; Pellegrini et al., 2019). While shelf-stable foods are wasted most due to being forgotten or ignored, perishable items are wasted most due to failure to be consumed in time. Revealing the root cause, Evans (2011) addressed the materiality of food as its fugacious nature contradicts with contingencies of everyday life. Generally, food that is perceived to be 'proper', healthy, and nutritious would be the most perishable ones such as green vegetables and fruits (Schanes et al., 2018). The time window within which they can be consumed, on the other hand, is too narrow. In addition, using these items to prepare a meal requires too much effort. Therefore, their consumption in time becomes a challenging task while struggling with the hectic rhythm of life (Evans, 2011, 2012). Perishable foods bought in abundance with the concern of eating proper food, then, presumably decay or degrade in quality before it could be consumed.

The next factor is related to how packaged food is labeled to inform consumers regarding the time frame that it could be consumed. Different labeling systems may confuse consumers while assessing the edibility of food and may lead to early disposal of it. Date labels, 'use by' and 'best before' indicate different meanings. The former infers the date until which food could be safely consumed and ought to

appear on the products whose microbial degradation carries health hazards. The latter indicates the date until which food could conserve its identical characteristics (freshness, taste, etc.) under the proper storage conditions. Confusion may also evolve out of a lack of knowledge about these meanings that is, however, discussed under the next category. Under this category, how **confusing date label (F2)** impacts HFW is investigated. It was proven that even though the difference between the two labels is known, consumers consider only the date without the text proceeding it (Hebrok & Heidenstrom, 2019). Through failure to consume food that passed best before date but that is still edible, lack of homogenous labeling system (Aschemann-Witzel et al., 2015; Farr-Wharton et al., 2014) leads to HFW (Falasconi et al., 2019; Fanelli, 2019; Wansink, 2018).

4.1.7 Knowledge and Awareness (G)

Undoubtedly, **lack of knowledge/skills/awareness (G1)** is one of the most interacting variables within HFW drivers system. Household food-management knowledge and capabilities such as appropriate storage, creative usage of leftovers and accurate portioning (Dobernig & Schanes, 2019; Hebrok & Heidenstrom, 2019), food literacy such as adequate interpretation of date labels (Aschemann-Witzel et al., 2015; Farr-Wharton et al., 2014) and awareness about the amount of food waste produced and its impacts (Baig et al., 2019; Graham-Rowe et al., 2015) are gathered under this concept. According to Baig et al. (2019), lack of awareness at the level of both policy and individual is a permanent driver of HFW. Parizeau et al. (2015) associated waste awareness with lower food waste generation. Fanelli (2019) indicated that consumers who are knowledgeable enough about cooking, food preservation, and date labels waste lesser food. Consumers' perceived behavioral control, in other words being confident in their capabilities to deal with HFW, has a strong and direct effect on the amount of HFW within the extended model based on the theory of planned behavior. Furthermore, the same model proposed that perceived capabilities to handle food are affiliated with the practice of leftover reuse (Stancu et al., 2016). Therefore, when consumers do not know how to perform 'food waste cooking' by using leftovers creatively (Shanes et al., 2018), then they fail to consume them and produce food waste (Abeliotis et al., 2016; Bravi et al., 2020). Due to lack of knowledge, reluctance to use own senses while assessing the edibility of

food could occur (Hebrok & Heidenstrom, 2019; Mattila et al., 2019). Farr-Wharton et al. (2014) argued that we should improve our knowledge about how consumers' knowledge about food and its edibility could be enhanced to avoid early disposal of food. Melbye et al. (2017) indicated that the knowledge level of consumers is positively correlated with their negative attitudes towards food waste. When a challenging task of portioning how much to cook, a cooking skill, cannot be fulfilled, it is likely to generate HFW due to cooking too much (Bravi et al., 2020; Hebrok & Heidenstrom, 2019).

4.1.8 Domestic Material Conditions (*H*)

Apart from the level of knowledge and interwoven relationship between domestic practices, domestic material conditions shape the storage practices as well. Among infrastructures used in households to manage food, the refrigerator dominates the discussions about the contribution of domestic material conditions to HFW through storage practices. The cellar is seen as an indispensable infrastructure for good storage practices in rural areas as well (Dobernig & Schanes, 2019), on the other hand, is not mentioned as an agent in the majority of studies examined. The main argument is that with **the limited technological advancements (*H1*)** they have, consumers are unable to perform waste-reducing storage practices. Those advancements are identified as fridge design allowing categorization and organization of food, large interior space, and optimal storage conditions in terms of temperature and humidity which are required to prolong the shelf-life of food.

There are conflicting accounts on how technological advancements provided by the fridge affect food-related practices and in turn the amount of food waste. One argument is that lack of enough space would retard systematic storage of food that is proposed to mitigate HFW (Farr-Wharton et al., 2014; Schanes et al., 2018). The opposite side revealed that access to larger fridges motivates for shopping less frequently and excessive purchasing that are mentioned before as food waste driving practices (Urrutia et al., 2019). Hebrok and Heidenstrøm (2019) maintained a point that consumers who have limited fridge spaces are keener on performing good storage practices. Furthermore, it is more likely that food is lost within a larger freezer

(Urrutia et al., 2019). That is why a smaller fridge could even be suggested to reduce HFW (Hebrok & Heidenstrom, 2019).

4.2 FCM and Structural Indices

After attaining data in the form of coding frequency (article numbers) for all possible types of causal relationships between system concepts, it was needed to be transformed into relationship strength to form an adjacency matrix. Throughout the transformation process, conflicting relationships were resolved by the methodology explained in Chapter 3 because in the adjacency matrix in a cell only one type of relationship can be defined. All possible causal relationships and computed relationship strengths were listed in Appendix D. By using relationship strength values in this list, the adjacency matrix (see Appendix E) constituting 35 elements was prepared. Final FCM was constructed on FCMapper Software by utilizing this adjacency matrix. Figure 9 demonstrates the FCM constructed for the HFW drivers system.

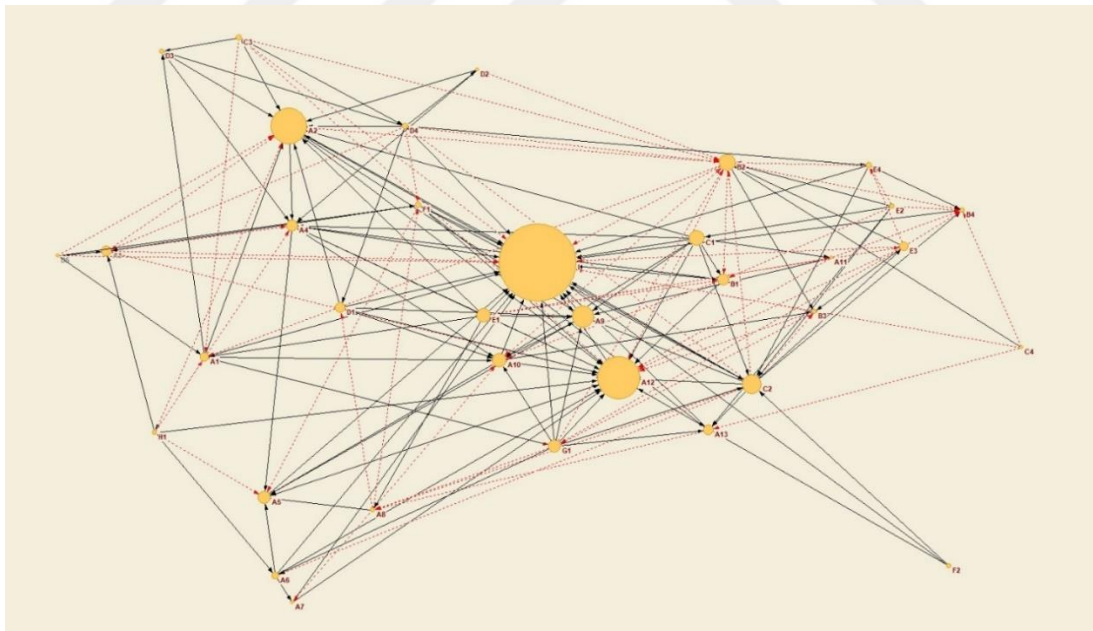


Figure 9 FCM of HFW system

Once the FCM was constructed, several structural analyses were conducted to indicate characteristic features of the HFW social system and its concept variables. The first indicator, the density of an FCM (D) is a connectivity index calculated by

dividing the number of relationships (R) by the number of all possible relationships (n^2).

$$D = \frac{R}{n^2} \quad (5)$$

As the number of connections in an FCM increase, density, indicating a higher level of complexity, increases as well. A highly dense structure is prompted to be able to offer sufficient recommendations. Otherwise, the resulting simple model would imply a limited representation (Ulengin et al., 2018). The density of the FCM derived within the scope of this study is 0.14 that could be defined as moderate compared to some of the studies in the literature (Cossette & Audet, 1992; Craiger et al., 1996; Morone et al., 2019; Ulengin et al., 2018).

Subsequent indices are related to concept types, understanding of which allows understanding the system structure. A system concept has outdegree and indegree values whose summation yield centrality value (C_i). Outdegree (od_i), the row sum of absolute values of a concept, indicates the cumulative strength of the relationships existing from the concept. Indegree (id_i), the column sum of absolute values of a concept, indicates the cumulative strength of the relationships entering the concept (Ozesmi & Ozesmi, 2004).

$$od_i = \sum_{j=1}^n \bar{W}_{ij} \quad (6)$$

$$id_i = \sum_{j=1}^n \bar{W}_{ji} \quad (7)$$

$$C_i = od_i + id_i \quad (8)$$

Centrality indicates the cumulative strength of connections; a concept has with other concepts in the systems (Ozesmi & Ozesmi, 2004). Centrality embodies all the connections between a concept and the rest of the system, therefore indicates the concept's contribution to the system (Ulengin et al., 2018). Centrality calculation was done for the concepts of respective FCM (Table 5.). HFW (I) is the most central concept of the system which is followed by three food-related household practices:

fail to consume (*A12*), excessive purchasing (*A2*), and cooking and serving too much (*A9*). After the most central practices, food safety and health concern (*C2*) appeared to be the most central concern and value/appreciation of food (*B2*) the most central attitude of the system.

Concepts are categorized under three types: receiver, transmitter, and ordinary (Ozesmi & Ozesmi, 2004). Concepts having non-zero *id* and zero *od* are the receiver concepts of the system. Receiver concepts indicate the outcomes and implications of a system (Eden et al., 1992), therefore, should be monitored to evaluate the system response to a change. In the resulted FCM, one receiver concept has emerged which is HFW (*I*). So, *I* will be the main performance indicator while comparing different scenarios in the subsequent stage of research.

Concepts having non-zero *od* and zero *id* are the transmitter concepts of the system. They can be regarded as concepts controlling the system but not affected by the system. That is why in a cognitive map whose causal relationships are well-elaborated, the number of transmitter concepts is expected to be low (Ozesmi & Ozesmi, 2004). On the other hand, for the respective FCM, the emergence of several transmitter concepts was expected as a natural consequence of consumer-level analysis. Associating with consumers' lifestyle and personal characteristics, the rhythms of everyday life (*E1*), economic concerns (*C3*), environmental concerns (*C4*), and past experiences (*E2*) have emerged as transmitter concepts. The accessibility / physical proximity of store (*D5*), and confusing date label (*F2*) are transmitter as well. Since these concepts lead to HFW independently of consumer preferences and choices, this result is not surprising as well. These concepts could signalize the important factors that should be kept in mind while introducing waste reduction solutions especially when it is necessary to segment target groups. Transmitter concepts were approached from this point of view in the subsequent stage of research. So, if a simulated scenario in the subsequent stage was associated with one or more of these controlling functions, they were controlled accordingly.

Concepts having both non-zero *id* and *od* are called ordinary concepts. In respective FCM, 28 concepts out of 35 concepts have emerged as ordinary concepts which are both drivers and affected of the system. The ratio of their *id* and *od* values

determines their role (more or less receiver or transmitter) within the system. FCM concept indices and categories mentioned above were summarized in Table 6.

Table 6 FCM Concept Indices and Categories

Concepts	C_i	Od_i	Id_i	Type
I. Household Food Waste	7.12	0.00	7.12	Receiver
A12. Fail to Consume	3.56	1.08	2.48	Ordinary
A2. Excessive Purchasing	3.36	1.24	2.12	Ordinary
A9. Cooking and Serving too much	1.72	0.68	1.04	Ordinary
C2. Food Safety and Health Concerns	1.68	1.28	0.40	Ordinary
B2. Value / Appreciation of Food	1.48	0.60	0.88	Ordinary
C1. Good Provider Identity	1.24	1.16	0.08	Ordinary
A10. Leftover Generation	1.20	0.56	0.64	Ordinary
A5. Lost/Forgotten/Ignored food items	1.12	0.60	0.52	Ordinary
E1. The Rhythms of Everyday Life	1.12	1.12	0.00	Transmitter
G1. Lack of Knowledge / Skills / Awareness	1.12	0.96	0.16	Ordinary
A4. Stockpiling	1.08	0.48	0.60	Ordinary
A3. Shopping Frequency	1.00	0.64	0.36	Ordinary
A13. Reluctance to use own senses	0.96	0.36	0.60	Ordinary
B1. Preference for Fresh and Variety	0.92	0.68	0.24	Ordinary
D1. Lack of Smaller Package Size	0.84	0.76	0.08	Ordinary
A1. Poor Shopping and Meal Planning	0.80	0.48	0.32	Ordinary
E3. Effort Devoted for Food Practices	0.80	0.72	0.08	Ordinary
A6. Poor Storage Practices	0.72	0.48	0.24	Ordinary
F1. Temporality / Perishability of Food	0.64	0.44	0.20	Ordinary
C3. Economic Concerns	0.64	0.64	0.00	Transmitter
D4. Magnitude of the Food Store	0.56	0.48	0.08	Ordinary
D3. Attraction of Special Offers	0.52	0.40	0.12	Ordinary
E4. Detachment	0.52	0.32	0.20	Ordinary
E2. Past Experiences	0.48	0.48	0.00	Transmitter
H1. Limited Technological Advancements	0.48	0.44	0.04	Ordinary
A8. Using Freezer	0.44	0.28	0.16	Ordinary
F2. Confusing Date Label	0.44	0.44	0.00	Transmitter
B3. Feeling of Guilt	0.44	0.24	0.20	Ordinary
D5. Accessibility / Physical Proximity of Store	0.44	0.44	0.00	Transmitter
B4. Suboptimality Perception	0.40	0.12	0.28	Ordinary
A7. Failure to Extend Lifetime of Food	0.40	0.16	0.24	Ordinary
D2. Low Food Prices	0.36	0.32	0.04	Ordinary
A11. Cooking Style	0.32	0.24	0.08	Ordinary
C4. Environmental Concerns	0.28	0.28	0.00	Transmitter

Note: Concepts are ranked by their centrality values

The final structural measure is the hierarchy index (h) that indicates the level of the hierarchy of a cognitive map. If h equals 1, it means that the cognitive map is fully hierarchical. On the other hand, if h of equals to 0, it means that the cognitive

map is democratic. Democratic maps are more adaptable to local environmental changes (Ozesmi & Ozesmi, 2004). h was calculated via the following equation.

$$h = \frac{12}{(n-1)n(n+1)} \sum_i \left[\frac{od_i - (\sum od_i)/n}{n} \right]^2 \quad (9)$$

For the respective FCM, h is 0.001 that is the lowest value among the values of various studies gathered together by Özesmi and Özesmi (2004). So, it can be confidentially stated that the respective FCM is highly democratic. All structural indices were aggregated in Table 7.

Table 7 Summary of Structural Indices

Indices	Values
Number of Concepts (n)	35
Number of Causal Relationships (R)	173
Number of Receiver Concepts	1
Number of Transmitter Concepts	6
Number of Ordinary Concepts	28
Density (D)	0.14
Hierarchy Index (h)	0.001

4.3 Individual Activation of System Concepts

The scenario analysis section was twofold. First, each concept was activated individually, and FCM was run to reach the steady-state point. Activations led to changes in other system concepts' values. The strength of the change was an indication for the evaluation of results and was divided into four. The strength of the change is:

- Strong if the value of change, $\bar{x} \geq 0.0100$
- Medium if $0.0010 \leq \bar{x} < 0.0100$
- Weak if $0.0001 \leq \bar{x} < 0.0010$
- Very weak if $\bar{x} < 0.0001$

All concepts were sorted by the value of change in dependent variable HFW (I) they caused in the long run. As it can be seen in Figure 10, food-related household

practices (category A) took place near the top in this ranking. This result was expected since, among the system concepts, household practices are the ones having the most direct causal relationship with HFW. Other non-A categories affect the dependent variable mostly as antecedents of practices. However, it should be noted that some practices fell behind the non-A category concepts. The most remarkable results were presented in detail.

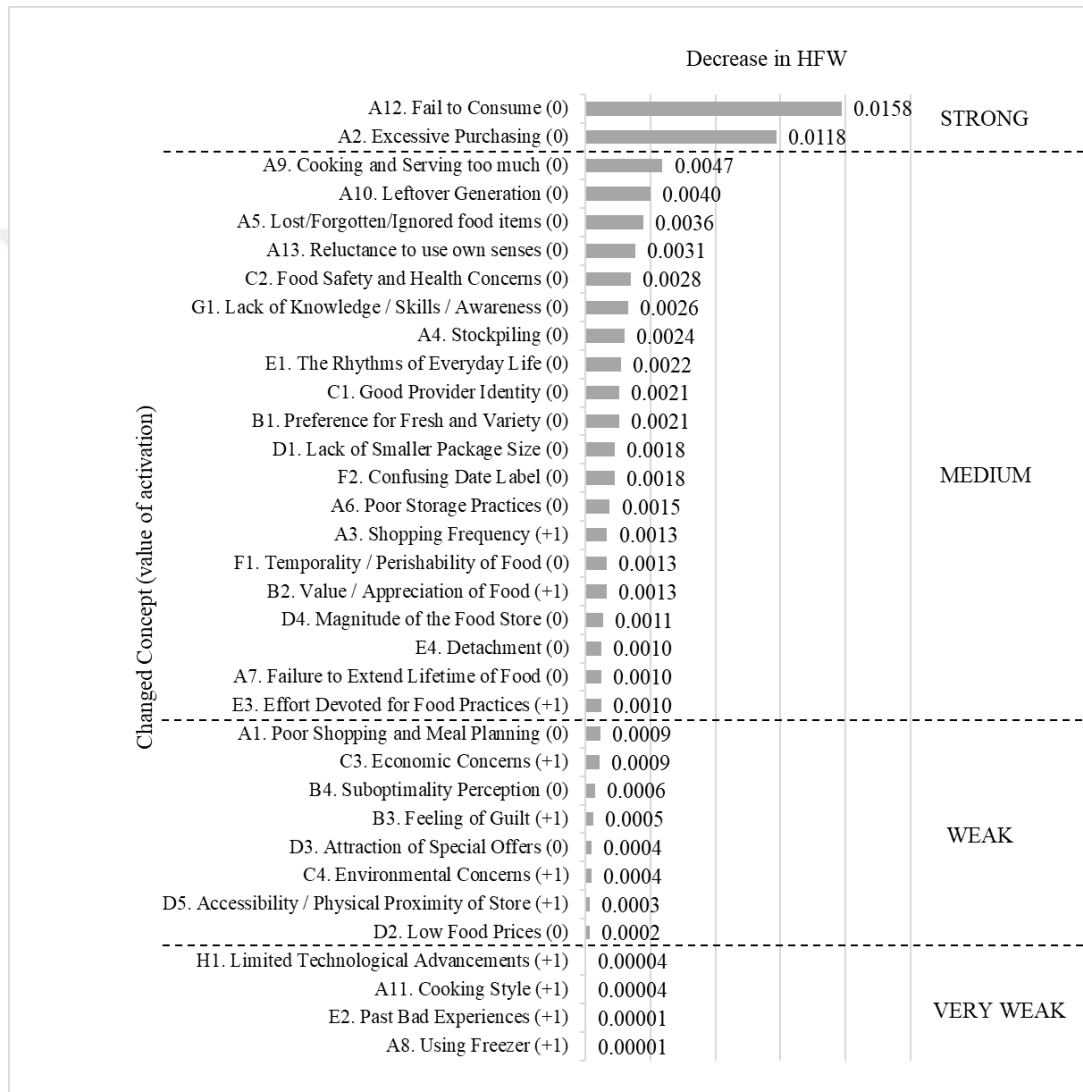


Figure 10 Influence of Individual Activations on HFW

Among the food-related household practices, failure to consume (A12) and excessive purchasing (A2) were standing out with their greatest potential for HFW reduction. They are the only concepts leading to strong change when activated individually. A12 came first in the ranking. The main reason for this result is that it is

the point that HFW is generated. In the series of practices, consumption is the latest ring that determines whether a food is wasted or not. It is the stage that we observe the consequences of previous wasteful practices such as excessive purchasing or cooking too much as well. Therefore, solutions targeting *A12* would yield greater results since it is possible to mitigate the negative impacts of previous practices as well. *A2* is the other practice that created a strong change in *I* because it is the initial ring that triggers the subsequent wasteful practices such as stockpiling or cooking and serving too much. To solve the problem in the beginning before the risk of waste grows, targeting *A2* would be rewarding. With the biggest fall in the ranking, *A12* and *A2* were followed by the practices *A9* (cooking and serving too much), *A10* (leftover generation), *A5* (lost/forgotten/ignored items), and *A13* (reluctance to use own senses) that caused a medium change in *I*.

The most intriguing outcome was that *A1* (poor shopping and meal planning), one of the most mentioned concepts as a prevalent factor causing HFW, led to a weak change in *I*. Due to its being the most confounding element of the system, the strength of its causal relationships was weakened with contradictory evidence (see Appendix D). This decreases its influence power within the system.

Being the most interacting variable within the system (see Appendix D), among the non-A category concepts, *C2* (food safety and health concerns) created the greatest change in *I* when activated alone. While designing a program to reduce HFW, targeting *C2* may not be straightforward as it can be deduced from the result. In other respects, as it can be the factor that hinders the behavior change, the rebound effect of a solution on *C2* should always be considered. In a similar vein, it is followed by *G1* (lack of knowledge/skills/awareness) that affects a great number of variables in the system. This finding appeared as a contradiction with the account stating that targeting solely increasing knowledge and awareness would not change the behavior of wasting food. The main inference regarding the success of campaigns targeting *G1* only, however, can be done by comparing with the ones targeting combined elements of the system. Still, it can be inferred that *G1* is an essential element of the system that should be focused on while fighting against HFW.

For some concepts, the direction of change necessary to reduce HFW could not be presumed before the behavior of the system was observed by simulating all alternatives. These concepts could have both negative and positive impacts on HFW by following different paths in the system. For instance, consumers with economic concerns have more tendency towards eating leftovers with the sense of thriftiness which is an HFW reducing factor. Meanwhile, consumers with economic concerns were more vulnerable to special offers and gaining a price advantage by purchasing larger packages which led to excessive purchasing, a practice causing HFW. That is why *C3* (economic concerns) activated twice by attaining '0' and '1' to figure out whether an increase or decrease in the concept would reduce *I*. As a result, when *C3* was 0, a medium increase in *I* was observed. When *C3* was 1, a weak decrease in *I* was observed (see Figure 10). Therefore, our system supports the argument states that consumers with higher economic concerns waste less amount of food. In addition, with this ranking, one of the most accentuated argument was confirmed. In our system as well, an increase in economic concerns reduces HFW more than an increase in environmental concerns.

The same situation was a matter of fact for *H1* (limited technological advancement). Lack of proper storage conditions was shown as the cause of poor storage practices that led to HFW. At the same time, it was proposed that promising large storage space that encourages less frequent shopping and excessive purchasing, *H1* could promote HFW generation. To figure out whether an increase or a decrease in *H1* would reduce HFW, similarly, two simulations were carried out. While a decrease in *H1* led to an increase in *I*, an increase in *H1* reduces *I*. Thus, on the contrary to the first impression, *H1* may not be an issue that needs to be solved primarily in the fight against food waste.

Another concept which follows different pathways and may influence HFW both positively and negatively is *E2* (past bad experiences). Consumers who experienced scarcity in the past might attach a higher value to food and avoid wasting it. On the other side, some might develop taste for abundance promoting wasteful practices such as stockpiling to leave behind bad memories. Moreover, consumers who experienced bad experiences such as poisoning could be overly cautious towards eating leftovers or could bone about early disposal of food. As a result of simulation

analysis conducting twice by attaining '0' and '1' to $E2$, we revealed that an increase in $E2$ reduces HFW. Even though the strength of change was very weak, we may say that facing difficulties about reaching food is an HFW reducing factor rather than a promoting factor.

Individual activations were done to gain insights about concepts influencing power in our system as well as to discover the direction of influence for some concepts having a diverse effect on the dependent variable, I . However, as practice theory foundations were discussed in Chapter 2, practices as a coordinated entity are bundles of activities. That is why targeting a single element would not be realistic as well as sufficient to break the routines. Therefore, in the second stage, scenarios, and their targeted concepts were determined based on the real cases proposed as solutions to reduce HFW in the literature. While identifying the scenarios to simulate in our system, food waste hierarchy (FWH), introduced in Chapter 2, was considered. Only the ones that aim to prevent food surplus generation by targeting root causes were selected. To be able to compare scenarios within a consistent domain, they were classified under 3 categories. Each category consists of scenarios whose core mandates are similar but approaches and naturally targeted concepts, therefore, outcomes are different.

4.4 Scenario Analysis of Group 1 – Raising Information Level

The most frequently enforced method of intervention has been the information and education campaigns to improve the knowledge, skills, and awareness of consumers to reduce HFW. Even though the effectiveness of these campaigns in creating behavior change was much-questioned due to their individualistic approach, their importance for HFW reduction was acknowledged. When we look at the rankings of individually activated concepts (see Figure 10), as a highly interacting component, the concept $G1$ (lack of knowledge/skills/awareness) has a significant role in our FCM as well. Throughout the world, numerous campaigns to raise awareness and improve kitchen skills and knowledge were initiated. In their review paper, Zamri et al. (2020) investigated many of those cases from different regions and compared them according to their approach, delivery methods, and impact. As a result of their analysis, they concluded that education programs engaging the community

through hands-on practices and incentives would yield the greatest impact. In connection with this account, we aimed to compare scenarios targeting *G1* in principal but utilizing different methods, affecting other additional elements of the system and consequently breeding HFW reduction in different extends. While scenario specifications were formed, real cases were referred. Table 8 introduced the specifications of three scenarios that were going to simulate on our FCM.

Table 8 List of Scenario Group 1

Scenarios	Targeted Concepts
S1.1 “Love Food Hate Waste” and “Save the Food”	G1. Lack of Knowledge/Skills/Awareness (0)
S1.2 Hellman’s Initiative “Restaurant with No Food”	A5. Lost/Forgotten/Ignored food items (0) A12. Fail to Consume (0) B1. Preference for Fresh (0) G1. Lack of Knowledge/Skills/Awareness (0) E3. Effort Devoted for Food Practices (0) A10. Leftover Generation (+1)
S1.3 The Cozinha Kitchen Program (Brazil)	A9. Cooking and Serving too much (0) A10. Leftover Generation (0) C3. Economic Concerns (+1) G1. Lack of Knowledge / Skills / Awareness (0)

Note: Rebound effects are in red, and controlled concepts are in green.

From group 1, the first scenario (S1.1) was designed through predicating campaigns aiming to raise awareness and knowledge such as “Love Food Hate Waste” from the UK (LFHW, n.d.) and “Save the Food” from the US (NRDC, n.d.). “Love Food Hate Waste” satisfied a 15% HFW reduction. “Save the Food” was able to deliver the message to 31% of participants, to convince 54% of them about the problem’s gravity, and to persuade 69% of them to how individual actions could create a difference. Message delivery techniques utilized were mainly adverts from all sorts of media, providing tips, tricks, or tools about food planning, food storage, and leftover cooking or community talks. To see the response of our FCM to such an information campaign, therefore, we suppose a scenario addressing the problem of lack of knowledge/awareness/skills successfully. Any rebound effect was anticipated. Consequently, only *G1* was activated with the value ‘0’, and the system was run on. System response was presented with significantly affected concepts. Weakly and very weakly affected concepts were excluded from the demonstration. All changes occurred as benefits. As can be seen in Figure 11, *A6* (-0.0210), *A13* (-0.0182), and

A12 (-0.0171) decreased strongly as a result of the intervention. Medium decrease in A1 (-0.0072), A10 (-0.0065), C2 (-0.0045) and A7 (-0.001) and medium increase in B2 (0.0076) and A8 (0.0077) were observed. Finally, the main benefit of the intervention was a medium change in I (-0.0026).

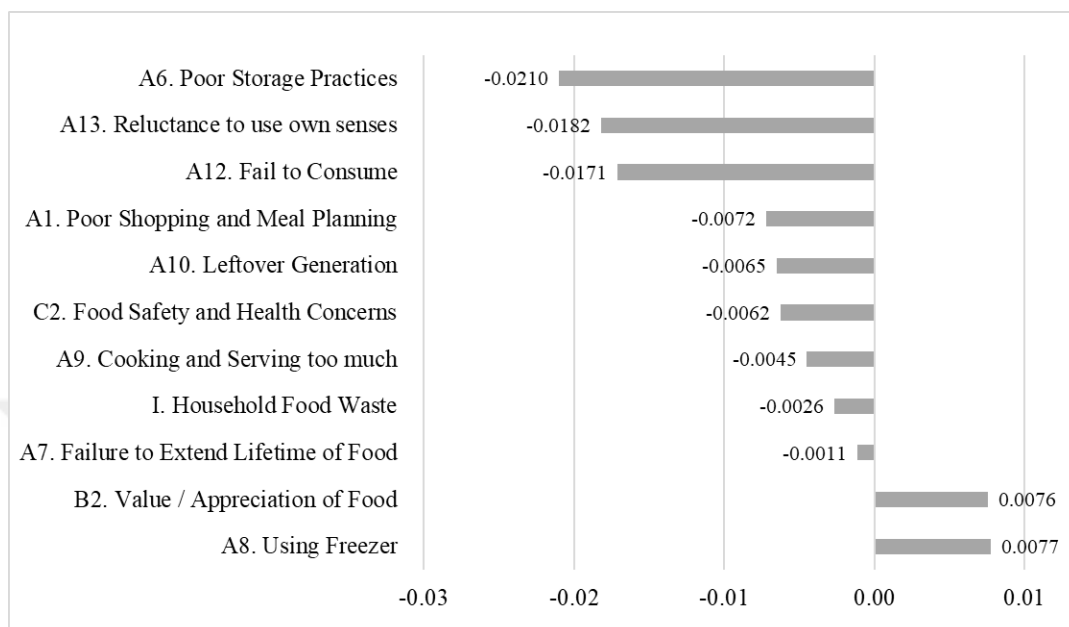


Figure 11 Results of S1.1

To be able to contribute to the debate about the inefficiency of knowledge and awareness campaigns, alternative scenarios that address multiple elements of our system by adopting different methods were selected. The second scenario, S1.2, is a Hellmann's initiative, 'the restaurant with no food' in Brazil that asks people to bring their leftovers thought to be useless to be turned into a five-star meal by professional chefs. Rather than a bill, a recipe of the meal is given to consumers, and the creation of the recipe is recorded as a video. In addition to this service, educational talks about food waste issues are organized. The main objective is still raising awareness and improving culinary skills but through a more engaging approach. People, who have difficulty in using up the food they have, are demonstrated how it is accomplishable rather than just posting recipes and expecting them to perform. They were demonstrated by the fact that meals cooked with leftovers could be transformed into tasty meals which would target the concept preference for fresh (B1) in our system. In addition, food brought to this restaurant is generally lost/forgotten/ignored food items (A5) which otherwise consumers would most probably fail to consume (A12). Therefore, together with G1, in this hypothetical scenario, B1, A5, and A12 were

activated by attaining '0'. Additionally, two rebound effects were anticipated. Regardless of the benefits provided by the initiative, people eat outside and devote lesser effort in this case (*E3*) which is an important element of our system. The decrease in the effort exerted to cook may make people unconcerned about a leftover generation (*A10*). Accordingly, *E3* and *A10* were activated by attaining respectively '0' and '1'. System response to activation of these 6 concepts was presented in Figure 12. Strong changes were observed in *A6* (-0.0210), *A13* (-0.0182), *A9* (-0.0148) as benefits and in *B2* (-0.0365) and *E4* (0.0157) as loss. Medium changes were observed in *A1* (-0.0067), *C2* (-0.0061), *A7* (-0.0011) and *A8* (0.0077) as benefits and in *B3* (-0.0052) and *B4* (0.0080) as losses. Finally, the main benefit of the intervention was a strong change in *I* (-0.0262).

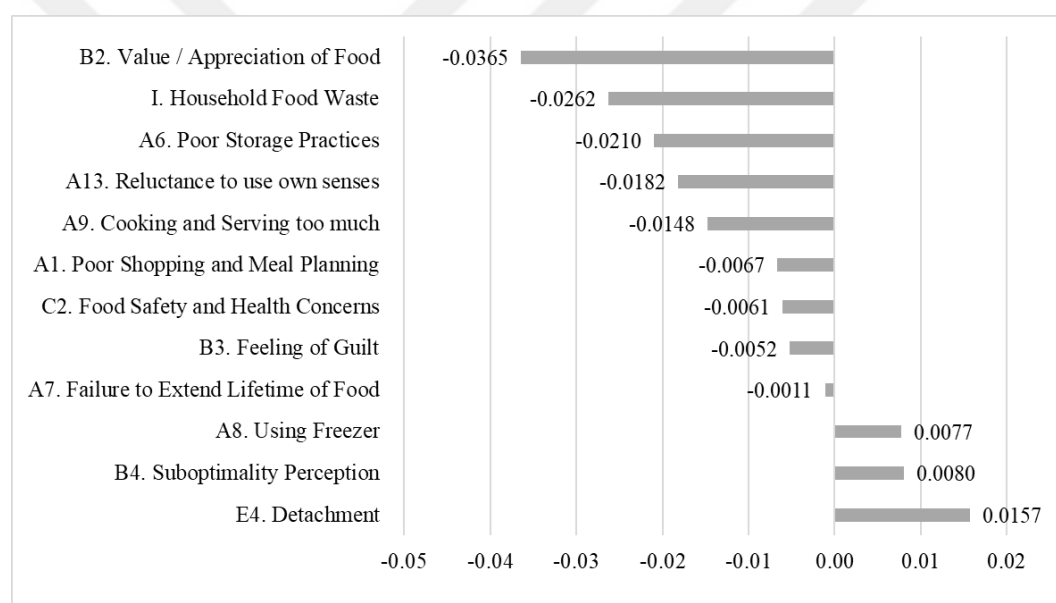


Figure 12 Results of S1.2

The third scenario (S1.3) was based on a program initiated in Brazil again. Targeting poor and vulnerable households, SESI's Programa Cozinha Brasil (Brazilian Kitchen Program) aims to avoid food waste in the kitchen. Through mobile learning kitchens, the program teaches participants to prepare affordable, nutritious, and tasty regional meals whose recipes are offered by nutritionists and chefs (FAO, 2013b). While fighting against lack of knowledge/skills/awareness (*G1*), using all parts of food is the main consideration of the program that could eliminate the leftover generation (*A10*) in our system. Emphasizing the content of food, the program would

orient participants from cooking and serving too much (A9) to cooking enough but nutritious meals. Any rebound effect was anticipated. Economic concerns (C3) were controlled since the program was designed for a particular group of people. Therefore, for the simulation of S1.3, G1, A9, and A10 were attained with ‘0’, and C3 was attained with ‘1’. System response to activation of these 4 concepts was presented in Figure 13. Strong changes were observed in A12 (-0.0233), A6 (-0.0210), A13 (-0.0182), A1 (-0.0112) and B2 (0.0121) as benefits. Medium changes were observed in A5 (-0.0086), C2 (-0.0062), A7 (-0.001) and A8 (0.0077) as benefits and in B3 (-0.0080), D3 (0.0037), D4 (0.0040) and A2 (0.0088) as losses. Finally, the main benefit of the intervention was a strong change in I (-0.0168).

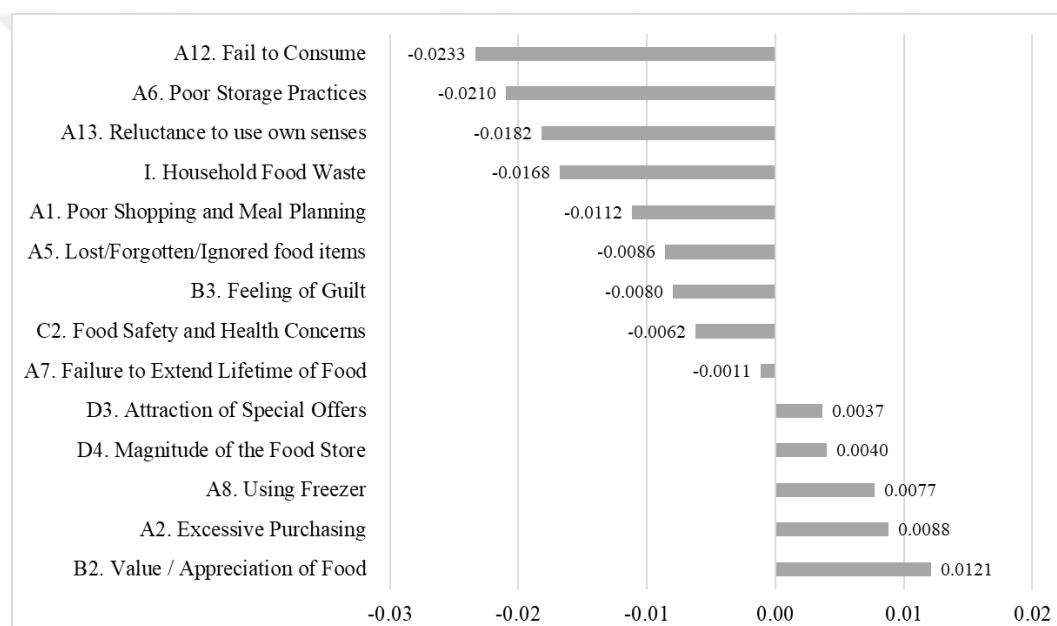


Figure 13 Results of S1.3

To summarize the results of scenario group 1 aiming to raise individuals’ knowledge/awareness/skill, S1.2 whose specifications underpinned by the initiative “Hellmann’s Restaurant with no Food” yielded the greatest decrease in HFW. It was followed by S1.3 based upon the Brazilian kitchen training program. Creating a strong change in HFW, S1.2 ranked second, and S2.3 ranked fourth among all scenarios (see Fig. 22). Finally, as expected, S1.1 predicated on “Love Food Hate Waste” and “Save the Food” brought up the rear by generating a medium change in HFW.

4.5 Scenario Analysis of Group 2 – Changing Food Provisioning Infrastructure

Under the second group, scenarios were identified based on cases addressing mainly the infrastructure of provisioning. The main argument is that adhering to the intention of buying what you need is a challenging task due to the traditional supermarket environment that encourages excessive purchasing (Dobernig & Schanes, 2019). Even though a consumer accomplishes to disregard the attraction of huge variety in a supermarket, s/he has little control over the amounts of items bought. Promotions such as buy-one-get-one-free (BOGOF) (Dobernig & Schanes, 2019; Farr-Wharton et al., 2014; Koivupuro et al., 2012; Porpino et al., 2015), the cost advantage of larger packages (Porpino et al., 2015) or unavailability of ingredients in smaller quantities (Evans, 2011; Urrutia et al., 2019; Wikstrom et al., 2019) are factors specific to traditional retail stores that cause HFW. Therefore, transformations in the operations of retail stores and alternative food provisioning systems were proposed as solutions to HFW. Based on four cases, four different scenarios shown in Table 9 were identified.

Table 9 List of Scenario Group 2

Scenarios	Targeted Concepts
S2.1 Tesco Initiative “Mix and Match” type of Promotion	A2. Excessive Purchasing (0) D1. Lack of Smaller Package Size (0)
S2.2 Alternative Food Networks: Farmer Markets	B2. Value / Appreciation of Food (+1) C3. Economic Concerns (0) D3. The Attraction of Special Offers (0) D4. The Magnitude of the Food Store (0) E4. Detachment (0) F1. Temporality / Perishability of Food (+1)
S2.3 Alternative Groceries: Zero-Packaged Groceries (ZPGs)	A1. Poor Shopping and Meal Planning (0) A2. Excessive Purchasing (0) A7. Failure to Extend Lifetime of Food (+1) C4. Environmental Concerns (+1) D1. Lack of Smaller Package Size (0) D3. The Attraction of Special Offers (0) D4. The Magnitude of the Food Store (0) E1. The Rhythms of Everyday Life (0) E3. Effort Devoted for Food Practices (+1) F2. Confusing Date Label (0) C2. Food Safety and Health Concerns (+1)
S2.4 Alternative Groceries: Online Shopping	A1. Poor Shopping and Meal Planning (0) D5. Physical Proximity of Food Store (+1) E3. Effort Devoted for Food Practices (0)

Note: Rebound effects are in red, and controlled concepts are in green.

From group two, the first scenario (S2.1) was based on a case in which an approach to special offers offered in retail stores was put on the table. Tesco has been actively contributing to the pursuits of food waste reduction via various initiatives. While determining the specifications of S2.1, on the other hand, we focused on how Tesco tackle with wastage of a particular product by addressing one of the most distinct characteristics exclusive to the store environment, special offers. In 2013 Tesco revealed that 68% of bagged salad (35% of it in the households) was thrown away due to multi-buy promotions. Tesco decided to change the type of special offer to change a shopping practice, excessive purchasing (A2), the root cause of waste. Mix-and-match types of promotions for smaller bags (D1) were put in place to prevent consumers from purchasing excessive amounts through multi-buys on large bags. As we know from individual activation results, extinguishing the attraction of special offers (D3) can create only a weak reduction in HFW. Therefore, we wanted to simulate S2.1 based on Tesco's initiative to reveal how targeting shopping practices by changing the type of special offers rather than removing the effect of D3 completely could improve this result. A2 and D1 were attained with '0', and the system was run on. Any rebound effect was anticipated. System response to activation of these 2 concepts was presented in Figure 15. Strong changes were observed in A4 (-0.0535), A9 (-0.0255), A12 (-0.0220) and A10 (-0.0150) as benefits. Medium changes were observed in H1 (-0.0099) and A5 (-0.0015) as benefits. Finally, the main benefit of the intervention was a strong change in I (-0.0148).

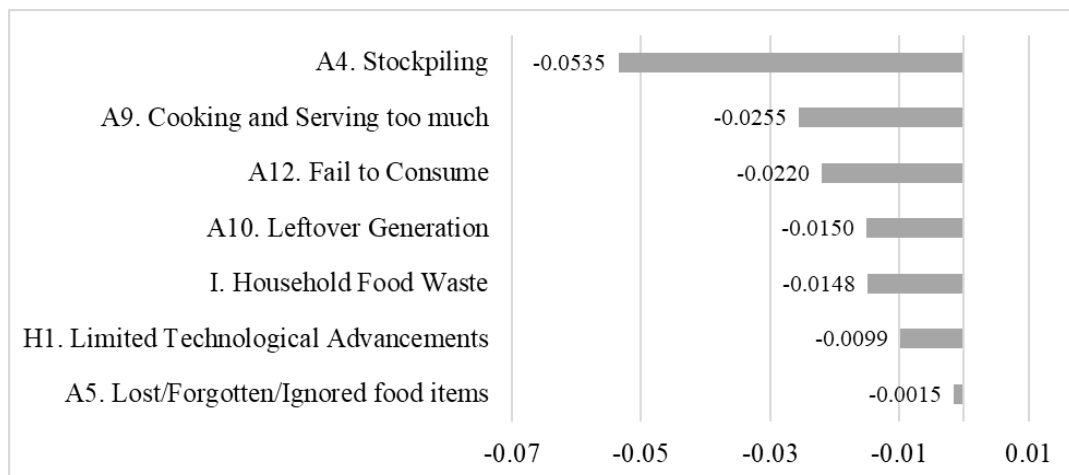


Figure 14 Results of S2.1

Inspiring from the proposition of Dobernig and Schanes (2019), alternative food networks (AFNs) underlay the second scenario of the second group (S2.2). They submitted farmer markets as a solution that could sort the lack of food appreciation problem out. Consumers purchasing from farmer markets would have the opportunity to know about local farmers and their growing practices and even to visit them. Enhanced knowledge about the production processes would address the issue of detachment (*E4*) and yield food appreciation (*B2*) that could reduce HFW generated through wasteful practices. The higher perceived value of food purchased from farmer's markets is originated from the locality of production as well as the higher prices. For this reason, we controlled economic concerns (*C3*) because price-oriented consumers would be more prone to opportunities provided by conventional retails and may not prefer farmer's markets. AFNs differentiate from conventional retail based on some infrastructural elements that were included in the specifications of the scenario. Shops of AFNs are smaller (*D4*), special offers (*D3*) are not prevalent elements of their operations and they provided a smaller assortment of products (Ribeiro et al., 2019). The latter factor generated a rebound effect. The majority of products purchased from farmer's markets would be fresh produces such as fruits and vegetables. The temporality/perishability of food products (*F1*) which is a food waste causing factor of the system would be higher. Therefore, for the simulation of scenario S2.2, *C3*, *D3*, *D4*, and *E4* were attained with '0', and *B2* and *F1* were attained with '1'. System response to activation of these 6 concepts was presented in Figure 16. Strong changes were observed in *A2* (-0.0765), *A4* (-0.0116) and *A3* (0.0135) as benefits. Medium changes were observed in *B4* (-0.0077), *D1* (-0.0077), *D2* (-0.0076), *B1* (-0.0043), *A10* (-0.0036), *A5* (-0.0036), *C2* (-0.0030) and *B3* (0.0078) as benefits and in *A12* (0.0012), *A13* (0.0028) and *A1* (0.0034) as losses. Finally, main benefit of the intervention was a medium change in *I* (-0.0014).

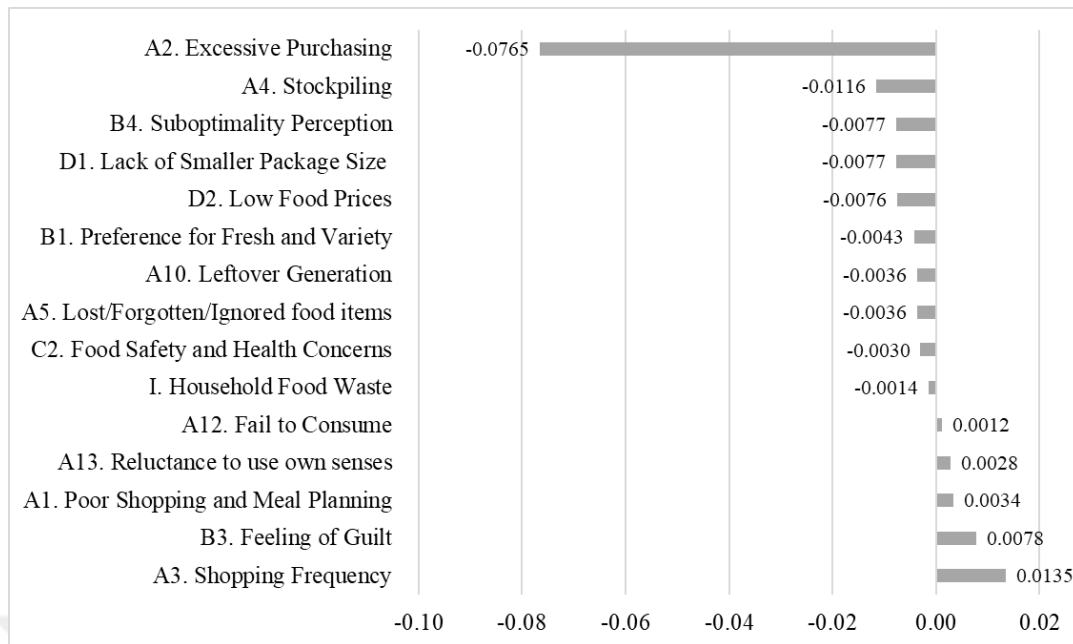


Figure 15 Results of S2.2

FAO (2013b) published a toolkit in which good practices were suggested for food waste reduction. One of those was an alternative chain of stores such as Granel in Spain, Unpackaged in the UK, and Effecarto in Italy in which foods are offered unpackaged. The third scenario of the second group (S2.3) was based on this business model and how it would affect consumers' practices. In this business model, customers are expected to bring their reusable containers to eliminate the environmental burden of single-use packs. When we approach its contributions to HFW reduction, on the other hand, the most obvious target of the model is the lack of smaller package size (*D1*). Unlike conventional retails, zero-packaged groceries (ZPGs) allow customers the freedom of deciding how much they need and purchase accordingly (FAO, 2013b). Letting purchasing how much they need; ZPGs would prevent excessive purchasing (*E2*).

As they introduce mostly local and organic products, ZPGs appeal to environmentally concerned (*C4*) consumers who want to eat healthily as well as do not want to generate package waste. In addition, Marken and Hörish (2019) found pro-environmental personal norms to be an important predictor of purchasing unpackaged food. Even though it was reported that consumers having economic concerns (*C3*) such as victims of the economic crisis in Spain are attracted by ZPGs

(FAO, 2013b), the concept was not included in scenario specifications. The reason for exclusion was conflicting judgments regarding ZPGs price competitiveness stated by ZPGs representatives investigated by Beitzel-Heineke et al. (2017). To provide a better understanding of ZPGs, the authors conducted interviews with representatives of seven stores across Europe. In addition to the ones mentioned so far, they deduced additional impacts of ZPGs.

Since customers have to bring their containers, they need to make shopping and meal planning (*A1*). Differently in conventional stores, the shopping experience in ZPGs is time-consuming since it requires providing and carrying different containers, filling them, and weighing them before and after filling. This effort devoted to a food-related practice (*E3*) by customers was reported as a strength of ZPGs rather than a weakness as it was positioned in our system. Impracticality and inconvenience, however, were one of the most mentioned barriers towards purchasing unpackaged food products by the participants in the research (Marken & Hörisch, 2019). Therefore, assuming that customers having very limited time would not prefer to shop ZPGs, the concept of the rhythms of everyday life (*E1*) was controlled for this scenario. Other key differences of ZPGs from conventional rivals are the absence of labels that targets the concepts of confusing date labels (*F2*) and the absence of brands that left no room for special offers (*D3*). Finally, arguing that variety should be created through meals by combining frequently used products, ZPGs respond day to day needs of customers. So, compared to huge supermarkets, ZPGs are smaller (*D4*) (Beitzel-Heineke et al., 2017). Two rebound effects were anticipated. Being used to bargain on the sense of security provided by brands and packages, food safety and health concerns (*C2*) might arise. Moreover, being used to longer shelf life mediated through packaging technology, consumers might fail to extend the lifetime of food during storing at home (*A7*).

Consequently, for the simulation of scenario S2.3, *A1*, *A2*, *D1*, *D3*, *D4*, *E1*, and *F2* were attained with '0', and *A7*, *C4*, *E3*, and *C2* were attained with '1'. System response to activation of these 11 concepts was presented in Figure 17. Since it is the most engaging scenario, S2.3 induced change in the greatest number of concepts. Strong changes were observed in *A4* (-0.0764), *A12* (-0.0670), *A9* (0.0509), *A10* (-0.0241), *E4* (-0.0163) and *B2* (-0.0332) as benefits and in *A8* (-0.0115), *A13* (0.0187)

and F1 (0.0136) as losses. Medium changes were observed in *H1* (-0.0099), *B4* (-0.0094), *D2* (-0.0076), *A5* (-0.0034), *A6* (-0.0031), *A3* (-0.0069) and *A11* (-0.0076) as benefits and in *G1* (0.0040) and *B1* (0.0063) as losses. Finally, the main benefit of the intervention was a strong change in *I* (-0.0292).

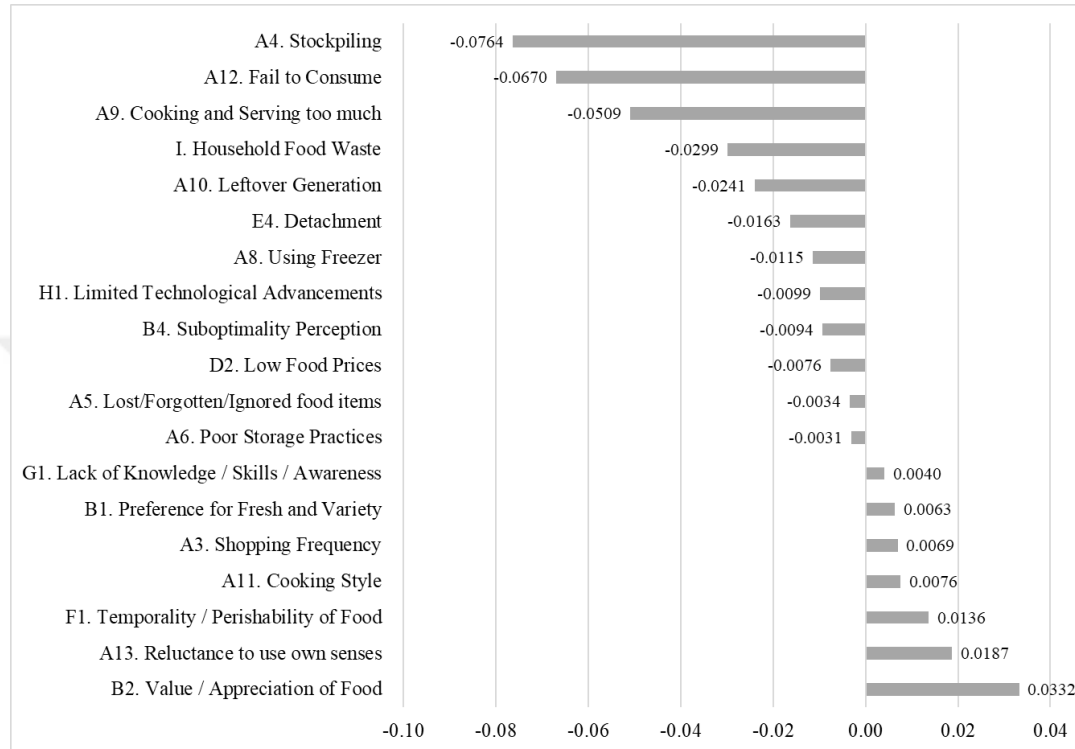


Figure 16 Results of S2.3

The last scenario analyzed under group 2 (S2.4) was online grocery shopping. Hebrok and Heidenstrøm (2019) found this new food provisioning service useful for fighting against food waste because inventory check would be an instinctive response while ordering online. Therefore, S2.4 addressed poor shopping and meal planning (A1) initially. Supposing that shopping online would have the same impact as shopping from physically closer food stores, we identified the physical proximity of food stores (D5) as the second benefit of S2.4. On the contrary its promising impacts, a rebound effect was reported in the literature as well. Online shopping, when it was compared to in-store shopping, was found to be a food waste likelihood increasing factor. When consumers shop online, they perceive lower purchase effort and reduces psychological ownership which in turn increases the likelihood of food waste (Ilyuk, 2018). Following the proposed underlying mechanism, we identified effort devoted to food practices (E3) as the rebound effect of S2.4. Consequently, for the simulation of

S2.3, A1 and E3 were attained with ‘0’, and D5 was attained with ‘1’. System response to activation of these 3 concepts was presented in Figure 18. Strong changes were observed in A2 (-0.0359) and A3 (0.0173) as benefits and in B2 (-0.0413), B3 (-0.0084), E4 (0.0157) and G1 (0.0163) as losses. Medium changes were observed in D3 (-0.0075), A10 (-0.0059) and A4 (-0.0025) as benefits and in F1 (0.0039), B4 (0.0081) and A12 (0.0097) as losses. Finally, the main outcome of the intervention was a weak increase in *I* (0.0006).

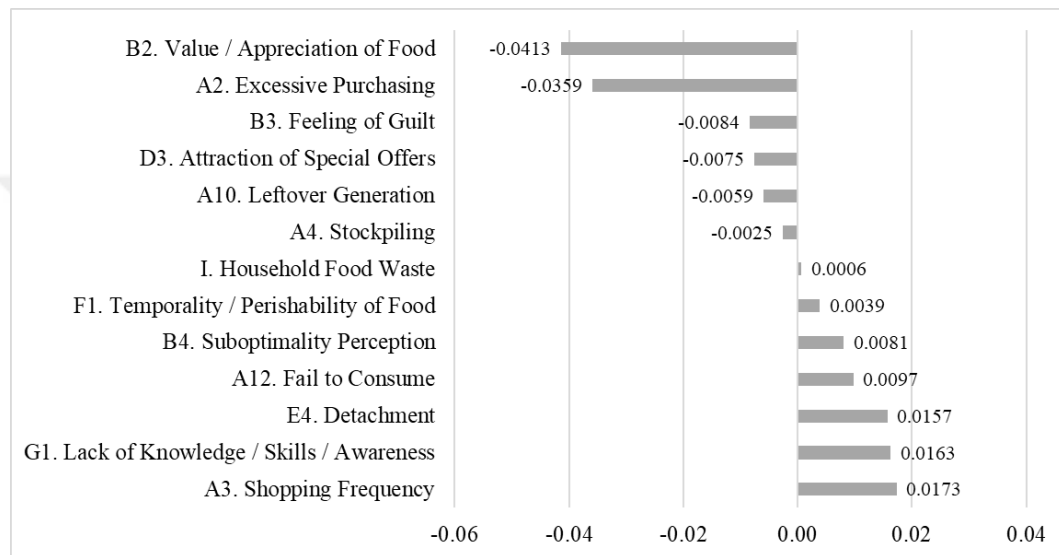


Figure 17 Results of S2.4

To summarize the results of scenario group 2 targeting food provisioning infrastructure, S2.3 based upon the ZPGs produced the greatest decrease in HFW and ranked first not just within the corresponding group but also in all scenarios (see Fig. 22). It was followed by S2.1 predicated on TESCO’s initiative that changed the promotion type. Creating a strong change in HFW, S2.1 also ranked fifth among all scenarios (see Fig. 22). Following scenario S2.2 based upon farmers’ market, on the other hand, led to a medium change in HFW. Finally, S2.4 specified according to online shopping brought up the rear as the only scenario among all scenarios that could not cause a reduction in HFW at all.

4.5 Scenario Analysis of Group 3 – Exploiting Technological Advancements

The third and final scenario group constituted scenarios based on solutions proposing HFW reduction via using technological advancements. Since non-humans such as food itself, food packaging, and fridges were significant agents within our system as supported by practice theory, cases targeting mainly these elements by exhibiting innovative solutions were selected and compared under this category. Table 10 demonstrates the specifications of three scenarios analyzed for the third category.

Table 10 List of Scenario Group 3

Scenarios	Targeted Concepts (rebound effects are in red)
S3.1 Intelligent Fridges (IF)	A1. Poor Shopping and Meal Planning (0) A5. Lost/Forgotten/Ignored food items (0) A12. Fail to Consume (0) C3. Economic Concerns (0) H1. Limited Technological Advancements (0)
S3.2 Intelligent Packaging (IP)	A6. Poor Storage Practices (0) A13. Reluctance to use own senses (0) F2. Confusing Date Label (0)
S3.3 Active Packaging (AP)	A7. Fail to Extend Lifetime of Food (0) F1. Temporality / Perishability of Food (0)

Intelligent fridges were the first one referred to identify the specifications of the first scenario under group three (S3.1). Suggesting the use of intelligent fridges (IF), Hebrok and Boks (2017) listed three different concepts one of which is ZmartFRI developed by Bucci et al. (2010). Supporting users in their daily routines, ZmartFRI's features were used to determine the S3.1 specification. As an appliance extended with a display system between the fridge and the consumer's mobile phone, ZmartFRI can alert the food items closer to their expiration dates together with a recipe that could be applied with them. With this feature, ZmartFRI addresses lost/forgotten/ignored food items (A5) and fail to consume (A12) in our system. Tracking the content of the fridge, ZmartFRI can prepare a shopping list and send it via SMS or email which targets poor shopping and meal planning (A1) (Bucci et al., 2010). Furthermore, via intelligent fridges, it is possible to alter problems caused by limited technological advancements (H1) which means larger space, better design for the organization, and optimal storage conditions in terms of temperature and

humidity. Any rebound effect was anticipated. However, due to its high purchasing cost, we supposed that consumers using intelligent fridges would not be economically concerned (C3) people. Therefore, our FCM was activated by attaining ‘0’ to *A1*, *A5*, *A12*, *C3*, and *H1*. System response to activation of these 5 concepts was presented in Figure 19. Strong changes were observed in *A2* (-0.0429), *D3* (-0.0151), *A6* (-0.0146) and *A9* (-0.0103) as benefits. Medium changes were observed in *D4* (-0.0077), *A10* (-0.0071), *A3* (-0.0069) and *B2* (0.0079) as benefits and in *A4* (0.0040) and *G1* (0.0082) as losses. Finally, the main benefit of the intervention was a strong change in *I* (-0.0214).

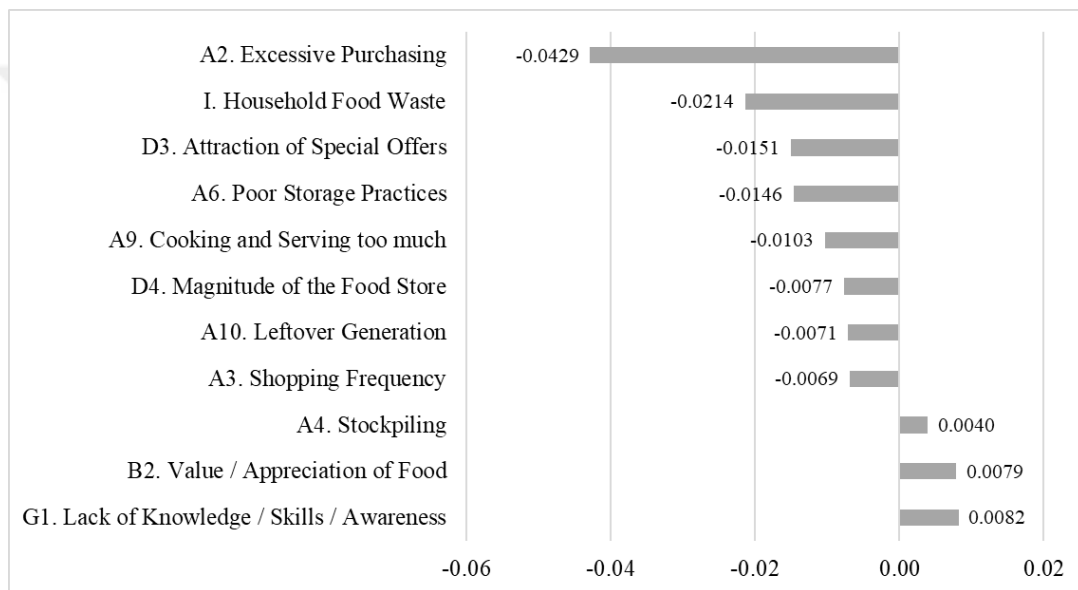


Figure 18 Results of S3.1

Predicating on intelligent packaging (IP), the second scenario of the third group (S3.2) was originated. Moving from the account that as food’s best companion, the packaging is a relevant agent that could inform about its condition, IP technology was developed. A package can be called “intelligent” as long as it can monitor the environment inside and outside the package, to detect the situation which is defined as undesirable for the food and how it is affected by this situation, and to give users notice of possible problems (Yam et al., 2005). Being one of those innovative products, Mimica Touch aims to substitute confusing date labels (*F2*) by creating a new tool to understand whether a food is fresh and safe for consumption. It is an intelligent label that becomes bumpy when the food inside the packaging has gone

bad. The company promises to reduce the amount of food wasted just because of the best before dates identified by the worst scenarios in which foods are not stored in proper conditions (Mimica, n.d.). From this respect, IP was supposed to create awareness about how poor storage practices can shorten (A6) lifetime of food and may mitigate practice change. Finally, in the absence of date labels, consumers were supposed to cast their reluctance to use their senses (A13) away. Therefore, for the analysis of S3.2, A6, A13, and F2 were activated by attaining '0'. System response to activation of these 3 concepts was presented in Figure 20. Strong changes were observed in A7 (-0.0320), A5 (-0.0217), C2 (-0.0200) and A12 (-0.0150) as benefits. A medium change was observed in A8 (0.0092) as a benefit. Finally, the main benefit of the intervention was a medium change in I (-0.0076).

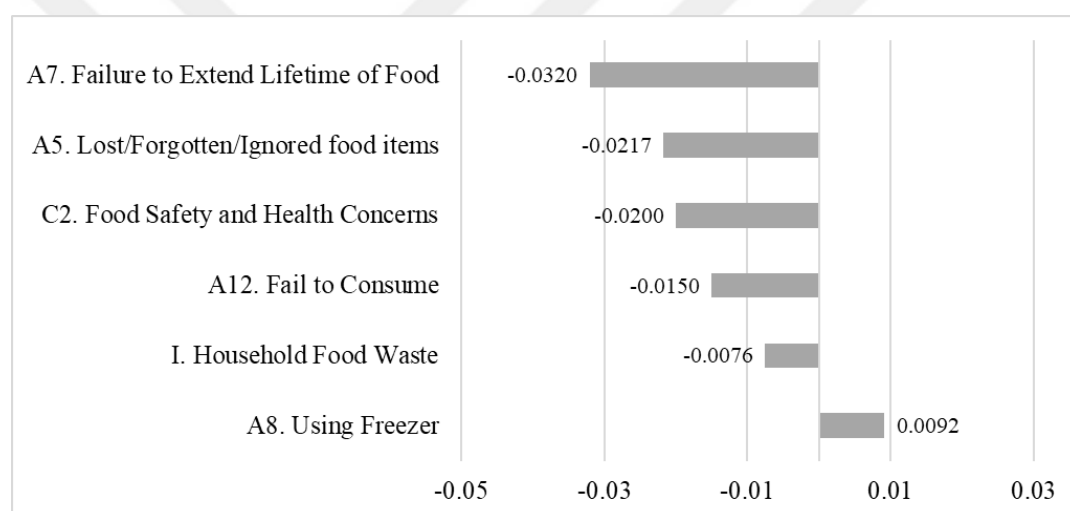


Figure 19 Results of S3.2

The third and last scenario of the third group (S3.3) was based on active packaging (AP) which is different than IP. Instead of just having a passive role of protection towards external threads, AP has an active role in extending the shelf-life of food through reactions with the internal atmosphere and the product (Icoz & Eker, 2018). AP technology has been used in various sectors such as meat, pastry, and fruits, and vegetables (Liegeard & Manning, 2020). Since fruits and vegetables are the food category mostly wasted due to their perishable nature, the AP trial conducted by TESCO drew a lot of attention. A strip that can absorb ethylene responsible for ripening and mold growth was placed in tomatoes and avocados packages without reflecting any cost increase to consumers. Initial trials were reported to be successful

and promising for the use of technology for a wider range of products (FAO, 2013b). With their feature of keeping fresh fruits and vegetables longer, ethylene absorbing strips target fail to extend the lifetime of food (*A7*) and temporality/perishability of food (*F1*). Therefore, for the analysis of S3.3, *A7* and *F1* were activated by attaining '0'. System response to activation of these 2 concepts was presented in Figure 21. Strong changes were observed in *A12* (-0.0103) as a benefit and in *A3* (-0.0141) as a loss. Medium changes were observed in *A13* (-0.0067) and *C2* (-0.0066) as benefits and in *A5* (0.0066) as a loss. Finally, the main benefit of the intervention was a medium change in *I* (-0.0024).

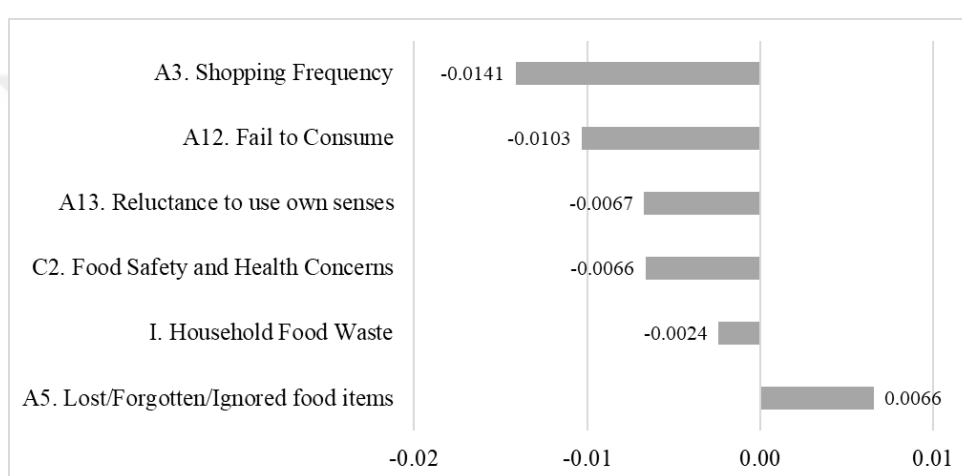


Figure 20 Results of S3.3

To summarize the results of scenario group 3 targeting domestic and packaging-related material context, S3.1 based on the technological advancement of intelligent fridges was the only scenario that created a strong decrease in HFW. Therefore, it ranked first among the corresponding group and third among all scenarios (see Fig. 22). It was followed by S3.2 predicated on intelligent packaging, thereafter by S3.3 predicated on active packaging both of which could generate a medium change in HFW.



CHAPTER 5: DISCUSSION

In this chapter, first, I will integrate and discuss the main findings of the study. Then, I will elaborate on theoretical, methodological, and practical implications as well as limitations of the study together with their connotations for future research.

5.1 Integration and Discussion of Findings

5.1.1 HFW System Concepts & FCM

The first stage of the three-staged methodology was the synthesis and the categorization of the HFW factors and their relationships through content analysis and expert opinion. As a result of this analysis, the list of the most influential HFW factors (see Table 5.) and the list of their relationships (see Appendix D) was identified through an iterative process of consolidation and tuning. When we consider the high level of complexity due to the great number of wide-ranging factors that are discussed in the literature, these two lists provide a well-refined framework of HFW that reflects the complexity with a holistic perspective.

Composing 35 concepts under eight categories and 173 relationships, this framework (explained in section 4.1) was transformed into an FCM (see Figure 9). Evident with the lower hierarchy index (0.14), the proposed FCM does not have a hierarchical structure on the contrary of other frameworks developed through systemic literature review studies (Aschemann-Witzel et al., 2015; Roodhuyzen et al., 2017). A hierarchical model in Figure 21, for instance, draws the possible paths towards waste by establishing the relationships between main categories.

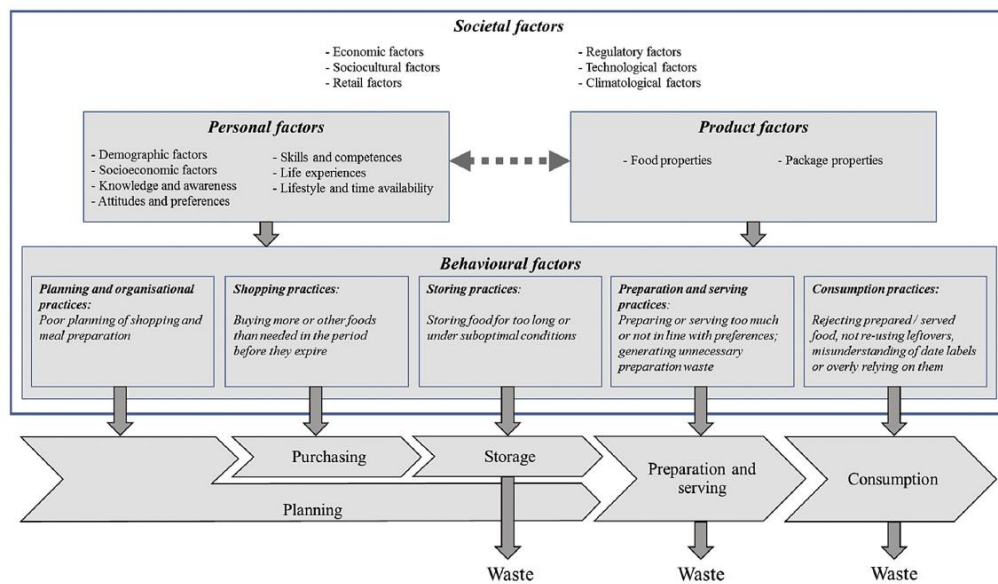


Figure 21 Conceptual Framework of Consumer-level Food Waste

(Reprinted from Roodhuyzen et al., 2017: p.46)

According to this hierarchical model, household practices are central, and all other factors are placed in order as antecedents. This approach seems to be well-grounded when it is aimed to provide an understanding by simplifying the complexity. However, it agglomerates subcategories into one category, therefore, cannot dissociate the individual contribution of each factor to the outcome.

Developing a democratic map, this study, on the other hand, aims to reflect the complexity as it is rather than simplifying it. Instead of regarding factors classified under the same category as tantamount, the FCM uncovers the individual contribution of each factor to the system. In this sense, as evident with structural analysis results, particularly the centrality values, our model shows a clear advantage over a hierarchical model. Indeed, the categorization of the system concepts was done by the structural analysis while the initial eight categories serve as the mainframe to facilitate narrating the HFW system.

According to the structural analysis, HFW is the only receiver, in other words, the outcome of the system. All other concepts are either ordinary (28 concepts) or transmitter (6 concepts) concepts of the system. What dissociates them from each other is their centrality (i.e. their impact) in the system. As evidenced in our study (see Table 6), there is not a hierarchical order between concepts in accordance with the category they belong to. Expectedly, centrality values as well as the individual activation results confirm the indisputable role of household practices. However, not all of them carry equal importance. While the particular A-category concepts (*A12* [3.56], *A2* [3.36], and *A9* [1.72]) are the most central ones, the rest of them spread throughout the list. In addition, non-A category concepts such as *C2* (1.68), *B2* (1.48), and *C1* (1.24) are also significantly central to the phenomenon of HFW. Therefore, through this democratic map, the study successfully demonstrates the disordered structure of factors whose interaction drives HFW.

5.1.2 Individual Activations & Scenario Analysis

A series of scenario analyses were conducted on the resulted FCM. First, to resolve the ambiguities driven by the complex nature of HFW drivers, system concepts were individually activated. The key insights gathered through the first stage were the identification of the most influential elements and the action mechanisms of some concepts that were uncertain. Second, ten scenarios inspired by the real intervention cases were simulated, and five of them (*S2.3*, *S1.2*, *S3.1*, *S1.3*, and *S2.1* respectively) were able to create a strong decrease in HFW (see Fig. 22).

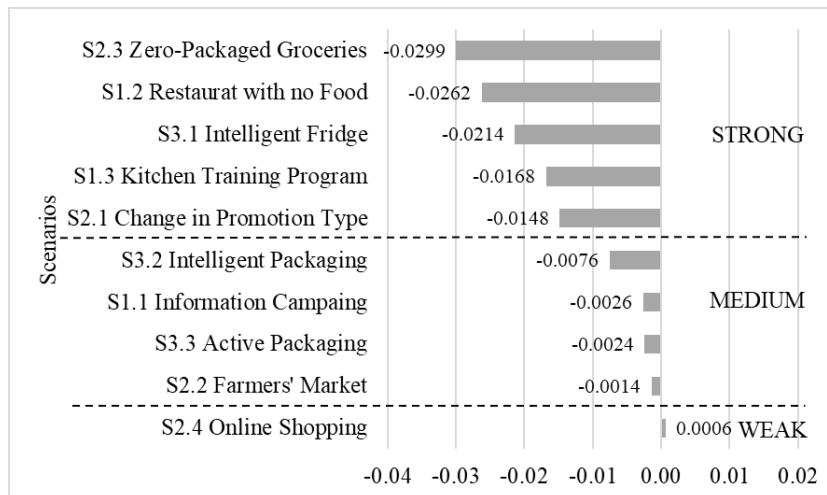


Figure 22 Ranking of all scenarios without classification

An obvious implication of this analysis is that these five alternatives should be seriously considered by researchers, policy makers, and other practitioners. In addition, when individual activation and scenario analysis results integrated and discussed together, more insightful implications surface. Therefore, after providing insights from the first stage, following subsections will dwell on the insights gathered from the integration of both stages.

5.1.2.1 Insights of Individual Activation Results

According to individual activations, the most influential elements of the system, at the same time the only ones causing a strong change in HFW alone, were A12 (fail to consume what is in the stock) and A2 (excessive purchasing). As can be recalled from the content analysis performed in the first stage, A12 and A2 were the most mentioned concepts (in 16 of 17 qualitative articles). In addition, they are found as the most central concepts. These findings alone highlight the significance of A12 and A2 in HFW drivers system. Therefore, interventions addressing those elements would have the highest potential in HFW reduction.

Overall, the most influential first six elements (*A12*, *A2*, *A9*, *A10*, *A5*, *A13* respectively) were A-category food-related household practices. This result supports the argument that to achieve significant results in HFW reduction, actual food handling practices should be targeted (Hebrok & Heidenstrom, 2019). However, researchers and decision-makers should keep in mind that many other A-category elements were ranked at the bottom of the list. The most remarkable one is *A1* (poor shopping and meal planning). Even though it was the third most mentioned practice (in 15 of 17 qualitative articles) after *A12* and *A2*, our study reveals its weak impact on HFW as the 23rd among 35 concepts. In other words, *A1* has received redundant attention in the literature as opposed to its low potential. In summary, this study precipitates that rather the six top-rated practices merit more the focus of future efforts of HFW reduction instead of trying to address the whole category.

This study provides considerable insight into non-A concepts that applied glue to the nexus formed by food-related household practices as well. After six top-rated A-category concepts, the most intriguing HFW-reducing impact was with the *C2* (food safety and health concerns) and *G1* (lack of knowledge/skills/awareness). Both concepts owe their power to being the most interactive concepts in the system. While *C2* is the antecedent of 13 concepts, *G1* influences 11 among 35 concepts (see Appendix D). On the contrary to the most obvious implication of this result, addressing either *C2* and *G1* alone might not be a straightforward task.

For example, challenge of addressing of *C2* emanates from its emergent nature through years of experiences, interactions, and exposures. Some antecedents of *C2* in our FCM such as good provider identity (*C1*), past bad experiences (*E2*), and the detachment from food's origin (*E4*) support this emergent nature. Similarly, Zhang et al. (2018) argued that food safety risk perception arise from a series of food safety crisis experience in the past. In addition, consumers are exposed to information regarding these cases in a heap from numerous sources such as media, governmental organizations, retailers, and consumer associations (Lobb et al., 2007). These are the factors that complicate addressing *C2*. Nevertheless, any possible rebound effect of an intervention on *C2* should not be overlooked because food safety risk perception

might accompany risk-reducing behaviors such as non-consumption (Yeung et al., 2010) or nonengagement in the case of an intervention that might obstruct its potential.

HFW literature supports this argument as well. Aschemann-Witzel et al. (2015) mentioned a trade-off between food safety and food wastage concerns and pointed the priority given to eliminate risks of food safety hazards as opposed to waste prevention. Due to this trade-off, for instance, people prefer to dispose of the leftovers considered unhealthy (Baig et al., 2019). This implies that even if an intervention promises a substantial reduction in HFW, it could fail if it disquiets consumers. Thus, the factors underpinning C2 should be addressed to increase an intervention's acceptability as suggested in the example of ZPGs which is explained in the next section.

5.1.2.2 Insights to Improve ZPGs' Potential

S2.3, specified in accordance with ZPGs, is the scenario that created the highest HFW reduction as well as only scenario that has a potential to increase food safety and health risk perception (C2). Our assumption based on the fact reported by Beitzén-Heineke et al. (2017) that establishing trust in food safety is a barrier to the expansion of ZPGs. The barrier is due to the lack of brands and packages providing traceability, instructions, and product origin information that are regarded as the reassurance of quality and utilized as risk relief strategies by consumers (Yeung et al., 2010). Despite its rebound effect on C2, S2.3 still generated the utmost reduction in HFW. This result, on the other hand, applies to the consumers who choose to shop from ZPGs even if they have food safety and health concerns. In other words, if ZPGs are not preferred by the vast majority due to mentioned barriers, they might fail to produce a significant HFW reduction overall even if they achieve to transform targeted practices of attracted customers.

Ultimately, barriers identified by Beitzén-Heineke (2017), especially the food safety concerns as the most interactive concept in the HFW drivers system, should be addressed to attract the maximum number of consumers and expand the potential impact of ZPGs. Moreover, hypothesizing if the barriers were eliminated, we repeated

the scenario analysis by keeping all the specifications but removing the rebound effect on *C2*. The potential impact of the scenario increased by approximately 15 %. Consequently, addressing the factors causing *C2* is crucial to gain higher preferability and to compound the HFW-reducing impact of ZPGs both per consumer and overall.

5.1.2.3 Insights to Improve Information Campaigns' Potential

As for *G1* (lack of knowledge/skill/awareness), we conclude that it should not be underestimated because of its interaction with many concepts and noteworthy individual influence on HFW. On the other hand, the effectiveness of interventions targeting just *G1* can be questioned since they do not target the factors outside the individuals and contextual food-related household practices (Evans, 2011; Hebrok & Heidenstrom, 2019). Indeed, scenario analysis showed that *S1.1* inspired by information campaigns could create a medium change and ranked 7th among the 10 scenarios (see Fig. 22). However, we argue that *G1*-targeting interventions might also create a significant impact by putting instructions into practice through innovative delivery methods that provide consumer engagement.

We analyzed two scenarios to confirm this argument. First, based on the campaign “Hellmann’s Restaurant with no Food”, *S1.2* addressed multiple elements including the most influential practices (*A12* and *A5*) apart from *G1* in a creative way that engages consumers into practice. *S1.2* became the second most influential scenario even though it was a primarily *G1*-targeting intervention. An explanation for this result can be targeting *A12* and *A5* that refer leftovers and re-use related practices. Investigating the consumers’ views, Kim et al. (2019) highlighted a supportive fact that leftover-reuse behaviors were the most preferred and effective (Schmidt, 2016) way for a campaign. Similarly, the third information-based scenario (*S1.3*) inspired by a Brazilian Kitchen Program targets, alongside *G1*, the most influential practices (*A9* and *A10*) that are also related to leftover re-use practices. As a consequence, *S1.3* became one of the scenarios that could create a strong decrease in HFW.

Another explanation of the remarkable impact of these scenarios is consumers’ active participation that provided a basis for us to assume that these campaigns could transform specified practices. Kim et al. (2019) also postulated the cruciality of

consumer participation while developing campaigns instead of utilizing passive methods such as providing instructions through mass media channels. Through mass communication it might be possible to reach large masses, however, this does not guarantee the acquisition of practice transformations since the message composed for general would not cover context-specific factors. Targeting on a smaller segment and its context-dependent practices (Hebrok & Heidenstrom, 2019), S1.3, for instance, assumed to accomplish transforming HFW driving practices. In short, both S1.2 and S1.3 showed that campaigns raising the level of information/skill/awareness can be highly effective in HFW reduction if they could engage consumers into highly influential practices with hands-on methods and within their contexts.

5.1.2.4 Insights on How to Use the Most Influential Concepts

Individual activations, in addition to the identification of the most influential concepts, resolved the ambiguities regarding the influence direction of some concepts. The most striking discovery was that while *H1* (limited technological advancement) increases, HFW decreases. This finding emerged by reflecting conflicting arguments regarding the relationship between *H1* and other elements of the system. As a consequence, the negative impact outweighed the positive impact of *H1* on HFW. Our initial reading of this finding was that *H1* should not be the primary concern while fighting against HFW. In other words, renewing fridges to have larger space and optimal storage conditions was excluded from the list of suggested HFW-reducing solutions. However, scenario analysis of S3.1 based on the technological advancement provided by intelligent fridges showed how it can be misleading to reach conclusions by only looking at the individual impacts.

S3.1 showed a different trend from a simple case of renewing fridges and became the third most effective scenario simulated. The main reason is that S3.1 did not just promise to improve domestic technology but also to assist consumers in their planning and consumption practices including *A5* and *A12* (two of the most influential six A-category elements). This situation highlights the importance of addressing multiple elements constituting the most effective practices to obtain significant HFW reduction through technology advancements.

A similar result was obtained from the fifth most effective scenario, S2.1 inspired by Tesco's initiative of changing promotion type. Even though attraction to special offers (*D3*) was reported as a driving force for waste generation, individual activations showed that the absence of the concept created only a weak decrease in HFW. Rather than proposing the complete removal of promotional offerings, S2.1, on the other hand, changed the type of special offer to transform one of the most influential shopping practices (*A2*). Alongside *A2*, *D1* (lack of smaller package sizes) is another element targeted by the scenario. Addressing only these two concepts, S2.1 accomplished to be inclusive of the scenarios creating strong HFW reduction.

This result is crucial also to understand the role of conventional food provisioning systems to tackle HFW with a holistic approach because the proliferation of ZPGs committed the highest reduction according to our analysis will not be an instant change. Rather, having a powerful position within FSC, food retailers can take the role of the locomotive to impel FW reduction in other stages through engaging in socially responsible behaviors (Devin & Richards, 2018). This could be achieved through changing promotion types as in scenario S2.1 as well as through accommodating the properties of ZPGs into the conventional store environment. After all, retailers can create a systemic effect by broadening their CSR perspective to transform consumption practices.

5.2 Theoretical Implications and Future Research

This research contributes to the HFW literature in two main ways: by exploring and demonstrating the complex nature of HFW drivers and by propounding implications. The first contributed literature, although providing extensive knowledge, is fragmented, split, and contextual due to the high level of complexity evolving out of multiplexed drivers and their multifaceted interrelationships. This has led authors for instance Roodhuyzen et al. (2017) and Schanes et al. (2018) to review systematically the previous work. Even though they managed to extract and integrate a wide range of factors as well as uncover the possibility of multiple causal pathways, prioritization of them could not be made. In this respect, this research contributed to the domain, alongside the reorganization of the existing knowledge, through the

prioritization of the most prevalent HFW drivers, ascertainment of the most influential ones, and resolution of the contradictory results.

Furthermore, our findings inform the literature that deals with examining the effectiveness of HFW interventions. This line of inquiry is relatively underdeveloped since the investigation of intervention consequences through reliable measurement methods is highly costly. This research, on the other hand, has managed to compare and prioritize interventions through a practical approach that integrates theory, previous research findings, and expert opinion. In this regard, the results of this research will open new trajectories for the development of the domain as the design and development of HFW-reducing interventions seem to challenge us for years.

5.3 Methodological Implications and Future Research

Aspects of FCM, as well as three-staged methodology specialized for this particular research, brought broad inclusivity and utmost completeness that are the most prevalent strength of this research. First of all, FCM transforms the qualitative, rich narrative into a quantitative account by using natural language as it is formulated. This enabled the inclusion of abstract constructs that are acknowledged to be effective, however, hard to measure.

Second, to quantify the relationship strength pairwise evolutions were made that also enabled the inclusions of a great number of diverse concepts. More importantly, pairwise evolutions made the extraction and the demonstration of complex interrelations and emergent multiple pathways possible. This means that even the blurred interactions of distant concepts were taken into consideration. In addition, quantification of relationships through pairwise evaluations seizes the wisdom of the lived experience and grasps the future possibilities instead of actual or self-reported FW amounts providing only a snapshot.

Third, through a content analysis of previous research, both the system concepts and their relationship types/strengths were explored. While the extraction of system concepts from secondary sources has been a common approach, the latter has typically been acquired through the primary data collection methods. Due to lack of

reference, a technique – based on the method proposed for adding individual maps together (Ozesmi & Ozesmi, 2004) – was developed for the computation of relationships' strength through content analysis. This technique provided us with an FCM unspecific to a context, or a population, therefore, is the most remarkable methodological contribution as well as the originality of this research. However, further work needs to be performed to establish its applicability and validity in other research contexts.

Another originality of the research is taking consumer perspectives into the center as they are the main source of accumulated experience and knowledge rather than relying on the professional opinion that has been the common approach previously. Selecting the articles studying consumer behaviors for the analysis, this research, therefore, provided an FCM informing intervention design from the stance of the consumer. Since this research aims to benefit from multiple resources and to obtain an unspecific model, secondary resources were used. However, through primary data collection methods, the utility of consumer centricity could be more explicit. For instance, consumers might be more open and collaborative when they are treated as experts. Thus, future consumer behavior research should focus on exploring the applicability and the utility of FCM as a participatory method.

Consumer centricity and the use of secondary resources were the critical methodological decisions grounding on substantive arguments discussed throughout this thesis. However, through the use of professional expert knowledge, another FCM may also be constructed. Construction of this second model would enable us to compare the two FCMs, elaborate more on the advantages and disadvantages of each approach, and as a result, provide more nuanced directions for future research.

5.4 Practical Implications and Future Research

Both individual activations of system concepts and scenario analysis reinforced by the real intervention cases have produced important practical implications for businesses, technology developers, policymakers, and NGOs designing interventions to reduce HFW. Individual activations show that the most influential elements of the system were food-related household practices *A12* and *A2*

followed by *A9*, *A10*, *A5*, and *A13* that merit more focus. Incentives that target to transform these practices will have the potential to yield a marked reduction in HFW. Providing order of drivers in terms of their impacts on HFW, this research, therefore, indicates starting point to canalize efforts of HFW reduction.

Individual activations of HFW drivers, although informative, can also be misleading. Results of some concepts having weak impact might lead decision-makers to leave aside associated intervention alternatives. For instance, the weak individual impact of *D3*, the attraction of special offers, does not mean that addressing *D3* to fight against HFW would be insignificant. S2.1 showed just the opposite that addressing *D3* can create a significant impact if one of the most influential practices is triggered alongside.

Even though not being observed in this research, the same condition can apply to *A1* which was found to have low potential as opposed to the redundant attention it receives in the literature. Consequently, while selecting among alternatives, the focus should be on the system response to the activation of all possible concepts rather than their isolated impacts. As pointed out in the previous paragraph, knowledge of factor prioritization will be valuable to initiate an effective intervention or to improve the effectiveness of an intervention, however, decision-makers should avoid reliance on it not to inhibit creativity.

Moreover, the scenario analysis inspired by the real intervention cases were tested under three categories: raising knowledge level, changing food provisioning infrastructure, and exploiting technological advancement. Results of the first category show that an informational intervention can create a significant impact if it strives also to transform the most influential practices through innovative delivery methods. This can be achieved through engaging consumers with hands-on methods instead of passively providing instructions. Such an approach requires targeting a smaller segment within their contexts. Therefore, customization of the FCM by the needs of the target group should be considered as will be discussed further next in the limitations section.

Results of the second scenario analysis, coping with the food provisioning infrastructure, showed that alternative groceries have the greatest potential in HFW reduction both within the category and among all scenarios. Therefore, their proliferation and penetration into consumption routines are crucial to speeding HFW reduction up. To this end, social entrepreneurs and sustainability investors should focus on the removal of barriers such as impracticality and inconvenience. Most importantly, the food safety and health concerns, C2 – which is the most interactive factor within the FCM as well as whose alteration is challenging – should be addressed. This requires also the regulatory efforts of policymakers as the new system attempts to change many established institutions of the conventional way of shopping such as promotional offerings and food packaging and labeling.

5.5 Limitations and Future Research

The research has some limitations. The resulted FCM might be still incomplete for some particular contexts. This was observed during a meeting with one of the experts consulted. She stated an opinion that ‘feeding the animals’ is a common disposal practice that influences the HFW behaviors in the context of Turkey where the protection of street animals is a contemporary issue. However, when we considered the objective and the scope of the study, we agreed with its exclusion due to its lower impact overall. Therefore, the scope of FCM provided by this study should be critically examined for the possibility of a need for an extension. As it was discussed in Chapter 3, FCM is a flexible method that enables the inclusion of extra concepts and relationships. After all, the proposed FCM can be used as it is, or customized to a specific context or a targeted group, or with changing temporal dynamics.

Another contextual limitation stemmed from the scarcity of research studying HFW in the developing parts of the world. This research aimed to obtain an FCM unspecific to a context, therefore, seek for diversity in sample selection as well as to demonstrate the complexity of the phenomenon as real-like as possible. The latter as the first-order aim required the inclusion of ample evidence to fill the relationship gaps in resulted FCM. Sought for ample evidence, thus, the balance was disturbed in favor of developed regions’ pan due to the shortcoming of studies conducted in

developing ones. So, further work in developing countries would help us to reach a model that represents both contexts equally.

This unbalance in the literature is a natural consequence of the fact that in developed countries the FW occurs in households whereas in underdeveloped countries in the primary stages of FSC. However, Lopez Barrera and Hertel (2021) have recently projected rapid growth of HFW in low and middle-income countries together with an increase in income levels and highlighted the precedence of interventions to change consumption behaviors. This underlines the need for further work exploring the drivers of HFW and their complex interrelationships in developing regions.

Finally, we presupposed the concepts that would change as a consequence of a particular intervention following the insights gathered from the literature. However, whether a scenario would actually induce presupposed changes and whether any unforeseen effect would show up have remained as important questions to resolve. Therefore, our findings suggest that future research should address these questions through longitudinal case studies or experimental studies by concentrating on the most promising alternatives (S2.3, S1.2, S3.1, S1.3, and S2.1 respectively). In addition, S2.4 requires further attention as well because during the Covid-19 pandemic period online food shopping has been in great demand and may have become an established practice in the post-pandemic period. This situation may have hindered the HFW-reducing efforts as S2.4 has created an increase in HFW. In this respect, future work should reflect upon how to eliminate the negative impact of online food shopping on HFW.

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APPENDICES



APPENDIX A: CODEBOOK

#	Categories	Nodes	Examples of Content Coded
1	Attitudes and Preferences	Desire to cook for specific purposes	* As part of the culture, Saudis love setting up lavish food tables during Eid festivals, weddings, parties, or informal get-togethers. They love to organize abundant banquets where wasting food is an indispensable feature. * Waste is common in festivals and special events where the customs is to provide more food than required.
2	Attitudes and Preferences	Feeling of Guilt	* The idea that good food cannot be thrown out was common to all of the households encountered in the study and they variously described themselves as ‘worrying’, ‘feeling bad’ or ‘feeling guilty’ about wasting food. * An individual who reports a feeling of guilt when throwing food is more likely to eat everything prepared, which reflects a reduced wasteful behavior.
3	Attitudes and Preferences	Preference for fresh and variety	* As a further trade-off especially underlined by the experts, consumers or their household members might simply dislike eating the same meal or any leftover food or they may even feel a certain disgust at the thought of storing or eating leftovers. * Really, I don’t like eating the same thing again, so I end up not eating it and throwing it out anyway.
4	Attitudes and Preferences	Suboptimality perception	* Regarding consumer food provisioning in terms of purchasing, a U.S. experiment found that consumers show little tolerance for visual imperfections * This means that consumers tend to expect high levels of perfection in appearance and freshness in modern supermarkets.
5	Attitudes and Preferences	Value / Appreciation of food	* Perception of the role of food (preferably a gift rather than a product) would be crucial to reduce food waste * A lack of knowledge about production processes makes it more difficult to appreciate the materiality of the produced good: for instance, the less you know and have experienced what it takes to produce a tomato, the harder it is to appreciate and ultimately value the growing process and the produce itself. * Some described how meals prepared by oneself were harder to throw away because one's time and resources were embodied in the meal
6	Concerns	Concern to decrease leftover ingredients	* One of the things that I try to do is batch cook stuff, so I don’t have like four or five half used ingredients kicking around. * In this example she finds a use for the ingredients that would otherwise be displaced by ‘something quick and easy from the local supermarket’
7	Concerns	Economic Concerns	* the overarching consumer price orientation and thus search for the optimal price-quality relation is a leading factor in food purchase. * While a share of food waste avoidance actions might be chosen in order to save money via “good housekeeping” * economic constraints and price orientation traditionally, and to a renewed extent during the economic crisis, are drivers of food waste avoidance both in the store, as well as in the household.

APPENDIX A (cont'd)

#	Categories	Nodes	Examples of Content Coded
8	Concerns	Environmental Concerns	* Consumers thus weigh priorities on waste avoidance for the sake of the environment versus safety for oneself and immediate others. * Interestingly, concerns about the environmental impacts of food waste turn out to be a minor motive to reduce wasteful behaviour.
9	Concerns	Food Safety and Health concerns	* People prefer to throw away the left- over food as they think it is unhealthy to eat or they do not want to eat the same food twice. * Past research has, for instance, enriched our understanding of how consumer food waste results from concerns about food risk and safety
10	Concerns	Good Provider Identity	* For example, consumers experience the inconvenience connected to avoiding food waste and have the wish to be a “good” food provider for the family (ensuring all member’s wishes and tastes are satisfied, potentially on the expense of cooking too much, allowing pickiness or throwing undesired leftovers out). * norms and social expectations, such as the need to entertain visitors instead of consuming food purchased for a preplanned mealtime, can cause behaviours that result in food wastage. * Moreover, a strong cultural norm of serving (more than) enough food and the fear of not being perceived as offering an abundance on special occasions and weekends contributes to overestimating the required portions for meals. * Brazil might be described as the land of abundance and diversity. Brazilians celebrate food when it is satisfying and filling, exalting its plenitude. Plentiful and mixed food is a cultural characteristic of Brazil
11	Concerns	Social Concerns	* Ethical reasons related to fairness (e.g., in light of worldwide hunger)
12	Consumption Practices	Failure to consume what is in the fridge in time	* When food is stored at home but not consumed * Amounts of food that remain un-eaten in consumers’ homes * In this example, food gets displaced and wasted as a result of a mismatch between the food that is provisioned and the food that is eaten within a given period of 7–10 days.
13	Consumption Practices	Reluctance to use own senses	* Consumers articulate and assess the quality of food in various ways, often relying on date labels for indicators as to whether a food is still edible * We observed our study participants to experience difficulties in judging food’s edibility. The findings showed consumers, particularly those who had negative experiences with food in the past, were prone to dispose of food prematurely. * Not trusting date labels blindly was also important in reducing food waste.
14	Disposal Practices	Feeding the animals	* leftovers are used to feed the animals. In the investigated sample, leftovers given to pets are not seen as waste. Families that own dogs, such as Marianne’s, tend to waste rice and beans.
15	Disposal Practices	Postponing the disposal	* procrastination when consumers defer the reuse of leftovers until these become inedible * procrastination, occasionally transforming valuable food (in particular leftovers) into waste by allowing the unpleasant disposal of food to be deferred.

APPENDIX A (cont'd)

#	Categories	Nodes	Examples of Content Coded
16	Domestic Material Conditions	Closeness of the fridge and the freezer to kitchen	* in the households where the fridge and freezer were both located in the kitchen, the freezer was more actively used to prolong the lifespan of some food items by moving them from the fridge to the freezer.
17	Domestic Material Conditions	Limited technological advancements	* Within the physical structure of the home, the space available for storing food may determine how much food is wasted * For respondents from the countryside, the cellar and/or a pantry presented integral elements in their storing strategies that kept food in their proper condition and extended processes of decay. * This statement illustrates that having adequate storage possibilities, that is, both enough space and optimal storage conditions (temperature and lighting conditions) was crucial for our respondents to ensure that purchased food was kept fresh.
18	Food Preparation and Serving Practices	Cooking and Serving too much	* They find the most frequently mentioned reasons for wasting food are that it could not be used in time, that too much had been prepared or served
19	Food Preparation and Serving Practices	Cooking style	* Tried and tested recipes instead of using what is left in the fridge (negative side) * Cooking from scratch (not using readymade mixture of ingredients) (positive side) * We also observed that all these mothers have the habit of cooking from scratch, which can lead to over-preparation and therefore to more waste.
20	Food Preparation and Serving Practices	Leftover generation	* Eight participants used time-saving strategies in meal-planning practices, including making leftovers on purpose to eat as future lunches and freezing meals in anticipation of future time scarcity.
21	Food Preparation and Serving Practices	Overpreparation	* The discarding of unconsumed food after cooking is also due to preparation problems such as burning the food.
22	Food Preparation and Serving Practices	Using self-service and smaller plates	* Waste can also be increased by the over- preparation of these stockpiled foods or by the over-serving that can occur because of large serving bowls or plates
23	Infrastructure of Provision	Accessibility/Physical Proximity of the food store	* The easy accessibility of food retail outlets also played a role when participants discussed the planning of meals. * Access to grocery stores was linked to over-purchasing, in one of two ways: through the lack of a conveniently located store or having access to a vehicle.
24	Infrastructure of Provision	Attraction to special offers	* the role that marketing promotions play in encouraging excess food purchases * Moreover, as food preferences often only take shape at the point of purchase (i.e., the supermarket), unplanned shopping trips make consumers more susceptible to marketing activities within the store.
25	Infrastructure of Provision	Huge food variety in a retailer	* Some reported that the big offers tempted them to buy more food than planned because they did not want to make a decision that they would regret later on.

APPENDIX A (cont'd)

#	Categories	Nodes	Examples of Content Coded
26	Infrastructure of Provision	Lack of smaller package sizes	* It appeared that 20%–25% of food was wasted due to packaging factors, such as packages being too large * One of the main reported reasons for wasting food mentioned by consumers is the package size of certain products which is often too large and not suitable for people who live alone or as couples
27	Infrastructure of Provision	Low food prices	* Economic affluence and welfare policies make food items available at subsidized rates, to the extent that most people can afford to waste. * Further, commercially processed food is a relatively cheap commodity, encouraging consumers to stockpile food or buy in bulk.
28	Infrastructure of Provision	The magnitude of the food store	* the type of store in which food is bought explains the amounts of food waste generated. * consumer food waste is higher in households that exclusively shop in large supermarkets compared to households that buy food in different shopping facilities.
29	Infrastructure of Provision	Visual appeal of food	* In such cases, participants would buy ‘whatever looks good’, or what appealed to their senses, changing plans as they shopped
30	Knowledge and Awareness	Lack of Knowledge/Skill/Awareness	* It is rooted in constraints of time and little priority given to food waste reduction behaviors, but also a lack of knowledge and know-how in storage and cooking. * This confirms prior research findings related to young people, which revealed their low abilities to manage food in the home due to their lower skills and experience in reusing leftovers and cooking appropriate portions
31	Package and Food Properties	Confusing date labels	* the current study shows that although most of the participants knew the difference between the two labels, the date independent of the text preceding it (best before or use by) is a trigger for food waste. * Generally, there is much confusion about different kinds of labels which may cause people to interpret any date label as a ‘use by date’, and therefore throw away all food items that ‘have expired’ although they are actually still safe to eat
32	Package and Food Properties	Familiarity/ Reusability	* Moreover, the participants who planned to use the same, familiar ingredients in several meals were generally more successful in putting all the food to use than those who tended to experiment more with unfamiliar ingredients and who planned very different dishes from day to day. * The current study shows that food waste often occurs when consumers handle food items that they are unfamiliar with
33	Package and Food Properties	Fresh/ Organic	* freshness (e.g., fresh food ingredients, meals cooked ‘from scratch’ and organic food) and taste are less frequently wasted than low- quality foods (e.g., processed food and less fresh food)
34	Package and Food Properties	Lack of improved packaging	* there have been significant advances in technology to extend the shelf life of products * Cheese is seldom sold in packaging with a reclosing function. As the environmental impact of cheese is very high when compared to its packaging, it can be justifiable to invest in more packaging material, adding reclosing functions and/or lower amounts of cheese per package.

APPENDIX A (cont'd)

#	Categories	Nodes	Examples of Content Coded
35	Package and Food Properties	Temporality/Perishability of food	* the materiality of foodstuffs themselves assume importance in terms of organizing the practices through which they must be used or otherwise wasted. * Usually, food that is healthy and nutritious is considered “proper”. Yet, buying healthy food does not necessarily result in its consumption but to an abundance of perishable foods that are at risk of wastage.
36	Planning Practices	Poor shopping and meal planning	* The use of a shopping list was especially frequent in the case of monthly shopping. * Consumers’ food waste behaviors are directly related to planning and shopping routines, having or lacking an overview of stocks, having or lacking knowledge about whether food can still be used and situational influences
37	Shopping Practices	Excessive purchasing	* It is possible for families to reduce wasteful behavior that starts in over-buying and cooking extra or cooking in huge quantities. * when more food is bought than needed * how the accumulation of food items that consumers never end up preparing or consuming—often referred to as “overbuying” or “overprovisioning”—comes about.
38	Shopping Practices	Shopping frequency	* as consumers reported that they shopped frequently and for small quantities, they pointed out that there was less need for storage space in their homes * For many, shopping more frequently reduced the need for advanced planning * a high frequency of shopping trips makes it unnecessary to store food that is easily perishable at home and could potentially reduce or prevent overprovisioning and thus food going to waste.
39	Shopping Practices	Shopping with car	* Access to grocery stores was linked to over-purchasing, in one of two ways: through the lack of a conveniently located store or having access to a vehicle. * Four participants with limited (or no) access to a car noted that they usually could not buy large amounts of food because they were not able to carry it home.
40	Social Relations	Eating together	* All these households point to their irregular schedules as the main reason for not eating together and also as the main reason to have to throw some food away. * the importance of rituals around the practice of eating, such as sitting at the table and eating together “as a family”, for transmitting food values to children.
41	Social Relations	Miscommunication between household members	* Further, observations showed that households with more than one person purchasing food are subject to miscommunication between household members, which led to multiple same-day purchases of a product.
42	Social Relations	Sharing	* our results could be explained by the fact that residents of Lebanese rural areas tend to be more religious; thus, they avoid wasting food and instead, they donate leftovers. * Leftover food has different value for different actors and it can be given to others to kill two birds with one stone: fulfilling the moral commitment to rescue value and sustain social relations.

APPENDIX A (cont'd)

#	Categories	Nodes	Examples of Content Coded
43	Socio-Temporal Context	Detachment of food consumption and production	* a lack of connection between consumers and the production of food and agricultural raw materials was suspected by one expert, with the effect that consumers have difficulty visualizing growth and production. Consumers thus might lack an understanding of variation in appearance or lack proper valuation of the food.
44	Socio-Temporal Context	Effort devoted for food practices	* Some described how meals prepared by oneself were harder to throw away because one's time and resources were embodied in the meal * Others also mentioned this as an issue when eating out, as one person explained, "it is easier to leave something [i.e., food] in a restaurant, because you do not cook yourself and do not understand the effort that went into making the meal"
45	Socio-Temporal Context	Increasing urbanization	* In terms of model estimates, households in rural areas show higher tendency to eat all food prepared in comparison to those in urban areas. This means that rural households contribute less to food waste generation. * First, we argue that rural environment might be special because of the opportunity to achieve long-term experience with plants and animals that shape human perception of value flows and reduces food wasting.
46	Socio-Temporal Context	Past Experiences	* For example, consumers having experienced scarcity during or after the Second World War hardly waste food. * Those consumers that have not experienced scarcity are often not overly concerned about ensuring the consumption of all the food they purchased before it expires. Therefore, they are more likely to throw out expired unconsumed goods
47	Socio-Temporal Context	The rhythm of everyday life	* Waste, then, often occurs when food is bought but not eaten because of unplanned events occurring in consumers' daily lives * Where public debates intimate that food, waste arises when individuals do not have enough time to cook 'properly' * The problem of keeping on top of ingredients in various states of decay was not exclusive to persons living alone and managing an erratic work schedule.
48	Storing Practices	Failure to extend storage life	* Cool, dark, and dry places offered optimal storing conditions for products such as potatoes, onions, and beer (amongst other items) and thus helped prolong their shelf life. * The most important feature of the refrigerator today is its ability to maximize shelf life; however, there may still be untapped potential for using the refrigerator to reduce the uncertainty of shelf life and create more use-occasions.
49	Storing Practices	Lost/Forgotten/Ignored Food Items	* Comments regarding the low visibility of food items within the refrigerator, particularly of items that were not located towards the front of shelves * tend to have a problematic relation with leftovers, which are often stored for too long in the refrigerator for reasons that go beyond not remembering that they had it in there.

APPENDIX A (cont'd)

#	Categories	Nodes	Examples of Content Coded
50	Storing Practices	Poor storage practices	Due to both lack of proper storage conditions and lack skills and knowledge. Lack of proper storage conditions is antecedents of 11 of others so cannot be combined with just them. * random and nonsystematic * items are placed where available * leads poor food preservation * lack of strategies (using special boxes for leftover to make them visible and to prolong shelf life) * under suboptimal temperatures
51	Storing Practices	Stockpiling	* Further, commercially processed food is a relatively cheap commodity, encouraging consumers to stockpile food or buy in bulk. * These external influences point to underlying promoters of particular food purchasing behaviours that contribute to domestic food waste, such as the stockpiling of food.
52	Storing Practices	Using freezer	* In some households, freezing was a practice deeply embedded in the routines of food shopping, storing, and dealing with leftovers in order to avoid food being wasted. * By contrast, in other households, freezing practices proved to be ineffective as the frozen food was occasionally forgotten.

APPENDIX B: List of Qualitative Articles

#	Reference	Journal	Title	Methodology	Context
1	(Aschmann-Witzel et al., 2015)	Sustainability	Consumer-Related Food Waste: Causes and Potential for Action	Literature Review + Expert Interviews	Europe
2	(Baig et al., 2019)	Saudi Journal of Biological Sciences	Food waste posing a serious threat to sustainability in the Kingdom of Saudi Arabia – A systematic review	Literature Review	Kingdom of Saudi Arabia
3	(Dobernig & Schanes, 2019)	International Journal of Consumer Studies	Domestic spaces and beyond: Consumer food waste in the context of shopping and storing routines	In- depth, qualitative study	Austria
4	(Evans, 2011)	Critical Public Health	Blaming the consumer – once again: the social and material contexts of everyday food waste practices in some English households	Ethnographic study	UK
5	(Evans, 2012)	Sociology	Beyond the Throwaway Society: Ordinary Domestic Practice and a Sociological Approach to Household Food Waste	Ethnographic study	UK
6	(Farr-Wharton et al., 2014)	Journal of Consumer Behavior	Identifying factors that promote consumer behaviors causing expired domestic food waste	Interviewing + Participant Observation	Australia
7	(Hebrok & Heidenstrom, 2019)	Journal of Cleaner Production	Contextualising food waste prevention - Decisive moments within everyday practices	Qualitative – Fridge Study	Norway
8	(Mattila et al., 2019)	Time & Society	Dances with potential food waste: Organising temporality in food waste reduction practices	Qualitative analysis of blog spots and in-depth interview	Finland
9	(Porpino et al., 2015)	International Journal of Consumer Studies	Food waste paradox: antecedents of food disposal in low income households	Observations, in-depth interviews, photographs	Lower-middle income Brazilian households

APPENDIX B (cont'd)

#	Reference	Journal	Title	Methodology	Context
10	(Porpino et al., 2016)	Journal of Food Products Marketing	Wasted Positive Intentions: The Role of Affection and Abundance on Household Food Waste	In-depth interviews, observations, and analysis of photos	Lower-middle income American families
11	(Revilla & Salet, 2018)	Journal of Cleaner Production	The social meaning and function of household food rituals in preventing food waste	Q-methodology and semi-structured interviews	Amsterdam
12	(Schanes et al., 2018)	Journal of Cleaner Production	Food waste matters - A systematic review of household food waste practices and their policy implications	Systematic Literature Review	-
13	(Sirola et al., 2019)	Sustainability	Mottainai! — A Practice Theoretical Analysis of Japanese Consumers' Food Waste Reduction	Mobile ethnography	Japan
14	(Sosna et al., 2019)	Journal of Cleaner Production	Rescuing things: Food waste in the rural environment in the Czech Republic	Waste composition analysis of household waste and ethnographic research	Rural region in Czech Republic
15	(Urrutia et al., 2019)	Resources, Conservation & Recycling	Material and visceral engagements with household food waste: Towards opportunities for policy interventions	Interviews, participant observation, and food waste measurements	Canada
16	(Wansink, 2018)	Journal of Food Products Marketing	Household Food Waste Solutions for Behavioral Economists and Marketers	Literature Review	-
17	(Wikstrom et al., 2019)	Sustainability	The Importance of Packaging Functions for Food Waste of Different Products in Households	Literature Study + Expert Workshop	Sweden

APPENDIX C: List of Quantitative Articles

#	Reference	Journal	Title	Methodology	Context
1	(Abeliotis et al., 2016)	Waste Management & Research	Food waste prevention in Athens, Greece: The effect of family characteristics	Questionnaire study	Greece
2	(Amirudin & Gim, 2019)	Resources, Conservation & Recycling	Impact of perceived food accessibility on household food waste behaviors: A case of the Klang Valley, Malaysia	Literature review + Survey	Malaysia
3	(Bravi et al., 2020)	Resources, Conservation & Recycling	Factors affecting household food waste among young consumers and actions to prevent it. A comparison among UK, Spain and Italy	Questionnaire study	UK, Spain and Italy
4	(Diaz-Ruiz et al., 2018)	Journal of Cleaner Production	Moving ahead from food-related behaviors: an alternative approach to understand household food waste generation	Questionnaire study	Spain
5	(van Dooren et al., 2019)	Waste Management	Measuring food waste in Dutch households: A synthesis of three studies	Survey	Dutch Households
6	(de Hooge et al., 2017)	Food Quality and Preference	This apple is too ugly for me! Consumer preferences for suboptimal food products in the supermarket and at home	An online choice experiment	Northern European
7	(Elimelech et al., 2019)	Sustainability	Exploring the Drivers behind Self-Reported and Measured Food Wastage	Physical waste, food purchases survey, questionnaire	Israel
8	(Ellison & Lusk, 2018)	Applied Economic Perspectives and Policy	Examining Household Food Waste Decisions: A Vignette Approach	Vignette methodology	U.S.
9	(Falasconi et al., 2019)	Sustainability	Such a Shame! A Study on Self-Perception of Household Food Waste	Questionnaire study	Italy
10	(Fanelli, 2019)	Sustainability	Using Causal Maps to Analyse the Major Root Causes of Household Food Waste: Results of a Survey among People from Central and Southern Italy	Exploratory on-line survey	Italy

APPENDIX C (cont'd)

#	Reference	Journal	Title	Methodology	Context
11	(Giordano , Alboni, Cicatiello, et al., 2019)	International Journal of Consumer Studies	Do discounted food products end up in the bin? An investigation into the link between deal-prone shopping behaviour and quantities of household food waste	Food waste diary experiment	Italy
12	(Giordano , Alboni, & Falasconi, 2019)	Sustainability	Quantities, Determinants, and Awareness of Households' Food Waste in Italy: A Comparison between Diary and Questionnaires Quantities	A diary and questionnaire study	Italy
13	(Ilyuk, 2018)	Journal of Retailing and Consumer Services	Like throwing a piece of me away: How online and in-store grocery purchase channels affect consumers' food waste	Experimental approach	-
14	(Jaeger et al., 2018)	Food Quality and Preference	Buy, eat or discard? A case study with apples to explore fruit quality perception and food waste	Eye tracking	Uruguay
15	(Janssens et al., 2019)	Foods	How Consumer Behavior in Daily Food Provisioning Affects Food Waste at Household Level in The Netherlands	An online survey	Netherlands
16	(Jereme et al., 2016)	International Journal of Advanced and Applied Sciences	Addressing the problems of food waste generation in Malaysia	Questionnaire study	Malaysia
17	(Mondejar-Jimenez et al., 2016)	Journal of Cleaner Production	From the table to waste: An exploratory study on behavior towards food waste of Spanish and Italian youths	Survey referring to PLS-SEM approach	Spain, Italy
18	(Jörisen et al., 2015)	Sustainability	Food Waste Generation at Household Level: Results of a Survey among Employees of Two European Research Centers in Italy and Germany	Online survey	Germany, Italy
19	(Lanfranchi et al., 2016)	British Food Journal	Household food waste and eating behavior: empirical survey	Survey	Italy
20	(Lee, 2018)	Journal of Cleaner Production	Grocery shopping, food waste, and the retail landscape of cities: The case of Seoul	Survey	South Korea

APPENDIX C (cont'd)

#	Reference	Journal	Title	Methodology	Context
21	(Mattar et al., 2018)	Journal of Cleaner Production	Attitudes and behaviors shaping household food waste generation: Lessons from Lebanon	Questionnaire study	Lebanon
22	(Melbye et al., 2017)	Journal of Food Products Marketing	Throwing It All Away: Exploring Affluent Consumers' Attitudes Toward Wasting Edible Food	Survey	Norway
23	(Parizeau et al., 2015)	Waste Management	Household-level dynamics of food waste production and related beliefs, attitudes, and behaviours in Guelph, Ontario	Waste weight + Survey	Canada, Ontario
24	(Pellegrini et al., 2019)	British Food Journal	Household food waste reduction: Italian consumers' analysis for improving food management	Questionnaire study	Italy
25	(Ponis et al., 2017)	Journal of Cleaner Production	Household food waste in Greece: A questionnaire survey	Questionnaire study	Greece
26	(Ratinger et al., 2016)	Agric. Econ. – Czech	Sustainable consumption of bakery products; a challenge for Czech consumers and producers	Survey + focus group	Czech Republic
27	(Russell et al., 2017)	Resources, Conservation & Recycling	Bringing habits and emotions into food waste behaviour	Questionnaire study	UK
28	(Qi & Roe, 2016)	PLoS ONE, Research Article	Household Food Waste: Multivariate Regression and Principal Components Analyses of Awareness and Attitudes among U.S. Consumers	Model estimation by referring to a national survey of U.S. residents	U.S.
29	(Schmidt, 2016)	Resources, Conservation and Recycling	Explaining and promoting household food waste-prevention by an environmental psychological based intervention study	Intervention study	Germany
30	(Schmidt & Matthies, 2018)	Resources, Conservation & Recycling	Where to start fighting the food waste problem? Identifying most promising entry points for intervention programs to reduce household food waste and overconsumption of food	Online survey	Germany

APPENDIX C (cont'd)

#	Reference	Journal	Title	Methodology	Context
31	(Secondi et al., 2015)	Food Policy	Household food waste behaviour in EU-27 countries: A multilevel analysis	The multilevel statistical perspective by referring to the 2013 Flash Eurobarometer survey	Europe
32	(Setti et al., 2016)	British Food Journal	Italian consumers' income and food waste behavior	A questionnaire study	Italy
33	(Stancu et al., 2016)	Appetite	Determinants of consumer food waste behaviour: Two routes to food waste	Survey	Denmark
34	(Visshers et al., 2016)	Journal of Environmental Psychology	Sorting out food waste behaviour: A survey on the motivators and barriers of self-reported amounts of food waste in households	Mail Survey	Switzerland and

APPENDIX D: List of Causal Relationships

Concept	Influence ³	# of Articles Coded ⁴	Strength of Influence ⁵	Concept	Influence	# of Articles Coded	Strength of Influence		
A1 →	A2 (+)	8	7	A8 →	A5 (+)	2	0.08		
	A2 (NR)	1			A7 (-)	2	-0.08		
	A10 (+)	1	-		-0.04				
	A12 (+)	1	0		D1 (-)	1	-0.04		
	A12 (-)	1			F1 (-)	1	-0.04		
	A12 (NR)	1	I (+)		1	0	0		
	D3 (+)	1	-		I (-)		1		
	G1 (-)	1	-	-0.04					
	A2 →	I (+)	12	A9 →	A10 (+)	7	-	0.28	
I (NR)		7	2		0.08	I (+)	10	-	0.40
I (-)		3	A10 →		A5 (+)	1	-	0.04	
A4		6		-	0.04	A12 (+)	1	-	0.04
A9		1		-	0.04	B2 (-)	1	-	-0.04
A12		3		-	0.12	B3 (+)	1	-	0.04
H1		1	-	0.04	I (+)	10	-	0.40	
I (+)		21	20	0.80	A11 →	A9 (+)	2	-	0.08
I (NR)		1				A12 (-)	3	-	-0.12
A3 →	A2 (-)	3	-	-0.12	A12 →	A5 (+)	2	-	0.08
	A4 (-)	2	-	-0.08		I (+)	25	-	1.00
	A12 (-)	2	-	-0.08	A13 →	A8 (-)	1	-	-0.04
	I (-)	10	9	-0.36		I (+)	8	-	0.32
	I (+)	1				A10 (-)	1	-	-0.04
A4 →	A5 (+)	2	-	0.08	B1 →	A12 (+)	11	-	0.44
	A10 (+)	1	-	0.04		I (+)	5	-	0.20
	A12 (+)	2	-	0.08	B2 →	A1 (-)	1	-	-0.04
	B1 (+)	1	-	0.04		A2 (-)	1	-	-0.04
	I (+)	6	-	0.24		A10 (-)	1	-	-0.04
A9	2	-	0.08	A12 (-)		2	-	-0.08	
A12 (+)	4	-	0.16	B1 (-)		1	-	-0.04	
I (+)	9	-	0.36	B3 (+)		2	-	0.08	
A5 →	A5	3	-	0.12	I (-)	7	-	-0.28	
	A7	4	-	0.16		A12 (-)	1	-	-0.04
	A12	1	-	0.04	G1 (-)		2	-	-0.08
	A6 →	I (+)	5	4	0.16	B3 →	I (-)	5	3
I (NR)		1	I (NR)				1		
A12		1	-	0.04	I (+)		1		
A7 →	A12	1	-	0.04					
	I (+)	3	-	0.12					

³ (+) is denoted for positive relationship, (NR) is denoted for no relationship and (-) is denoted for negative relationship between concepts and influenced concepts.

⁴ Derived from the analysis of 51 qualitative and quantitative articles. Some concepts may have diverse influence on another. Second column under # of articles column is for adjusted # of articles coded for the most powerful relationship.

⁵ Strength of influence was gathered through normalization of article numbers between 0 and 1. Most powerful influence was referred by 25 articles between A12 and I. So, its strength was assigned with 1 and others normalized accordingly.

APPENDIX D (cont'd)

Concept	Influence	# of Articles Coded		Strength of Influence	Concept	Influence	# of Articles Coded		Strength of Influence
B4 →	B2 (-)	1	-	-0.04	D1 →	A2 (+)	7	-	0.28
	I (+)	2	-	0.08		A9 (+)	4	-	0.16
C1 →	A2 (+)	6	-	0.24		A10 (+)	2	-	0.08
	A4 (+)	2	-	0.08		A12 (+)	2	-	0.08
	A9 (+)	7	-	0.28		I (+)	4	-	0.16
	A10 (+)	1	-	0.04	A2 (+)	4	-	0.16	
	A11 (+)	1	-	0.04	A4 (+)	1	-	0.04	
	A12 (+)	4	-	0.16	B2 (-)	3	-	-0.12	
C2 →	B1 (+)	2	-	0.08	D3 →	A2 (+)	9	-	0.36
	C2 (+)	2	-	0.08		A4 (+)	1	-	0.04
	I (+)	4	-	0.16		I (+)	2		
	A2 (+)	3	-	0.12	I (-)	1	0	0	
	A6 (-)	1	-	-0.04	I (NR)	4			
A8 (-)	1	-	-0.04	D4 →	A2 (+)	2	-	0.08	
A9 (+)	3	-	0.12		A3 (-)	1	-	-0.04	
A12 (+)	2	-	0.08		B2 (-)	1	-	-0.04	
A13 (+)	9	-	0.36		D1 (+)	1	-	0.04	
B2 (-)	1	-	-0.04		D2 (+)	1	-	0.04	
B3 (-)	1	-	-0.04		D3 (+)	1	-	0.04	
B4 (+)	1	-	0.04		E4 (+)	1	-	0.04	
D4 (-)	1	-	-0.04		F1 (-)	1	-	-0.04	
E3 (+)	1	-	0.04		I (+)	4			
F1 (+)	2	-	0.08		I (NR)	1	3	0.12	
C3 →	I (+)	7			D5 →	A1 (+)	1	-	0.04
	I (NR)	1	6	0.24		A2 (-)	3	-	-0.12
	A1 (-)	1	-	-0.04		A3 (+)	5	-	0.20
	A2 (+)	5	-	0.20		F1 (+)	1	-	0.04
	A12 (-)	1	-	-0.04		I (-)	1	-	-0.04
C4 →	B2 (-)	1	-	-0.04	E1 →	A1 (+)	3	-	0.12
	D3 (+)	1	-	0.04		A2 (+)	1	-	0.04
	D4 (+)	1	-	0.04		A4 (+)	2	-	0.08
	I (-)	7				A8 (+)	1	-	0.04
	I (NR)	1	6	-0.24		A9 (+)	6	-	0.24
A13 (-1)	1	-	-0.04	A11 (-)		1	-	-0.04	
B2 (+)	2	-	0.08	A12 (+)		7	-	0.28	
B4 (-)	2	-	-0.08	B1 (-)		1	-	-0.04	
I (-)	5			E3 (-)		1	-	-0.04	
I (NR)	3	2	-0.08	I (+)		5	-	0.20	

APPENDIX D (cont'd)

Concept	Influence	# of Articles Coded		Strength of Influence	Concept	Influence	# of Articles Coded		Strength of Influence
E2 →	A13 (+)	1	-	0.04	F2 →	A12 (+)	1	-	0.04
	B1 (-)	1	-	-0.04		C2 (+)	1	-	0.04
	B2 (+)	3	-	0.12		I (+)	5	-	0.20
	B4 (-)	1	-	-0.04		A1 (+)	1	-	0.04
	C1 (+)	2	-	0.08	G1 →	A6 (+)	3	-	0.12
	C2 (+)	2	-	0.08		A8 (-)	1	-	-0.04
	E4 (-)	2	-	-0.08		A9 (+)	1	-	0.04
E3 →	A12 (-)	3	-	-0.12		A10 (+)	1	-	0.04
	B2 (+)	5	-	0.20		A12 (+)	5	-	0.20
	B3 (+)	1	-	0.04		A13 (+)	3	-	0.12
	B4 (-)	1	-	-0.04		B2 (-)	1	-	-0.04
	E4 (-)	2	-	-0.08		B4 (NR)	1	-	0
	G1 (-)	1	-	-0.04		C2 (+)	1	-	0.04
	I (-)	6	5	-0.20		I (+)	8	7	0.28
E4 →	I (NR)	1				I (NR)	1		
	B2 (-)	3	-	-0.12	H1 →	A1 (-)	1	-	-0.04
	B4 (+)	1	-	0.04		A2 (-)	2	-	-0.08
	C2 (+)	1	-	0.04		A3	1	-	0.04
F1 →	I (+)	3	-	0.12		A4 (-)	1	-	-0.04
	A3 (+)	2	-	0.08		A5 (-)	2	-	-0.08
	A5 (-)	1	-	-0.04		A6 (+)	3	2	0.08
	A12 (+)	2	-	0.08		A6 (-)	1		
	A13 (+)	1	-	0.04		A12 (+)	2	-	0.08
	C2 (+)	1	-	0.04		I (+)	1	0	0
	I (+)	4	-	0.16		I (NR)	1		

Note: Relationships highlighted with red were the weakest ones among the types possible between two concepts.

APPENDIX E: Adjacency Matrix

n_i	A ₁	A ₂	A ₃	A ₄	A ₅	A ₆	A ₇	A ₈	A ₉	A ₁₀	A ₁₁	A ₁₂	A ₁₃	B ₁	B ₂	B ₃	B ₄	C ₁	C ₂	C ₃	C ₄	D ₁	D ₂	D ₃	D ₄	D ₅	E ₁	E ₂	E ₃	E ₄	F ₁	F ₂	G ₁	H ₁	I		
A ₁	0	0.28	0	0	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0	-0.04	0	0.08	
A ₂	0	0	0	0.24	0	0	0	0	0.04	0	0	-0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0.80	
A ₃	0	-0.12	0	-0.08	0	0	0	0	0	0	0	-0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.36	
A ₄	0	0	0	0	0.08	0	0	0	0	0.04	0	-0.08	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.24	
A ₅	0	0	0	0	0	0	0	0	0.08	0	0	0.16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.36	
A ₆	0	0	0	0	0.12	0	0.16	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.16	
A ₇	0	0	0	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.12	
A ₈	0	0	0	0	0.08	0	-0.08	0	0	-0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.04	0	0	0	
A ₉	0	0	0	0	0	0	0	0	0	0.28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.40	
A ₁₀	0	0	0	0	0.04	0	0	0	0	0	0	0.04	0	0	-0.04	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.40	
A ₁₁	0	0	0	0	0	0	0	0	0.08	0	0	-0.12	0	0	0	0	-0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
A ₁₂	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	
A ₁₃	0	0	0	0	0	0	0	-0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.32	
B ₁	0	0	0	0	0	0	0	0	0	-0.04	0	0.44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.20	
B ₂	-0.04	-0.04	0	0	0	0	0	0	0	-0.04	0	-0.08	0	-0.04	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.28	
B ₃	0	0	0	0	0	0	0	0	0	0	0	-0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.08	0	-0.12	
B ₄	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	
C ₁	0	0.24	0	0.08	0	0	0	0	0.28	0.04	0.04	0.16	0	0.08	0	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.16	
C ₂	0	0.12	0	0	0	-0.04	0	-0.04	0.12	0	0	0.08	0.36	0	-0.04	-0.04	0.04	0	0	0	0	0	0	0	0	-0.04	0	0	0	0	0.04	0	0.08	0	0	0.24	
C ₃	-0.04	0.20	0	0	0	0	0	0	0	0	0	-0.04	0	0	-0.04	0	0	0	0	0	0	0	0	0	0	0.04	0.04	0	0	0	0	0	0	0	0	-0.24	
C ₄	0	0	0	0	0	0	0	0	0	0	0	0	-0.04	0	0.08	0	-0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.08	
D ₁	0	0.28	0	0	0	0	0	0	0.16	0.08	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.16	
D ₂	0	0.16	0	0.04	0	0	0	0	0	0	0	0	0	0	-0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
D ₃	0	0.36	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
D ₄	0	0.08	-0.04	0	0	0	0	0	0	0	0	0	0	0	-0.04	0	0	0	0	0	0	0	0.04	0.04	0.04	0	0	0	0	0	0	0.04	-0.04	0	0	0.12	
D ₅	0.04	-0.12	0.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0	0	-0.04	
E ₁	0.12	0.04	0	0.08	0	0	0	0.04	0.24	0	-0.04	0.28	0	-0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.04	0	0	0	0	0.20	
E ₂	0	0	0	0	0	0	0	0	0	0	0	0	0.04	-0.04	0.12	0	-0.04	0.08	0.08	0	0	0	0	0	0	0	0	0	0	0	0	-0.08	0	0	0	0	
E ₃	0	0	0	0	0	0	0	0	0	0	0	-0.12	0	0	0.20	0.04	-0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.08	0	0	-0.04	0	-0.20
E ₄	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.12	0	0.04	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.12	
F ₁	0	0	0.08	0	-0.04	0	0	0	0	0	0	0.08	0.04	0	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.16	
F ₂	0	0	0	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.20	
G ₁	0.04	0	0	0	0	0.12	0	-0.04	0.04	0.04	0	0.20	0.12	0	-0.04	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.28	
H ₁	-0.04	-0.08	0.04	-0.04	-0.08	0.08	0	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	