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Modeling the Relationships Among the Driving Factors of Food Waste in Indonesian City

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Abstract:

Purpose: Food waste in cities has become a pressing issue not only in developed countries but also in developing countries like Indonesia. The main objectives of this study are to (1) identify the relationships among the driving factors of food waste in Indonesian cities by considering the perspective of food industry practitioners and academics and (2) model the relationships among the driving factors of food waste to reduce food waste in Indonesian cities.

Design/methodology/approach: The driving factors of food waste were selected from literature reviews and corroborated using in-depth interviews with practitioners and academics. A combination of two methods comprising Interpretive Structural Modelling (ISM) and *Matrice d'Impacts Croisés Multiplication Appliqué un Classement* (MICMAC) were used to construct the hierarchical model the relationship among the driving factors of food waste based on their driving power and dependence power.

Findings: There are three key players in the food waste chain in urban areas in Indonesia: households, restaurants, supermarkets/markets. Fifteen driver factors on food waste based on the supplier-input-process-output-customer (SIPOC) framework were identified. The relationship among the driving factors of food waste was constructed in a hierarchical structure of food waste in Indonesian cities. With this, strategic action is formulated to reduce food waste.

Practical implications: The proposed model of the driving factors of food waste can inform the city government on how to manage food waste. Likewise, the findings can assist Indonesian households, restaurants, and markets/supermarkets in minimizing their food waste. The ISM approach's hierarchical structure allows practitioners to better identify the objectives for reducing food waste in Indonesian cities.

Originality/value: Previous studies have not examined and specifically modeled the relationships among the driving factors of food waste in Indonesian cities with three main players, i.e., households, restaurants, and supermarkets or traditional markets.

Keywords: driving factors, food waste, interpretive structural modelling (ISM) approach

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1. Introduction

Food waste in cities has become a pressing concern as it contributes most to global food waste in developed and developing countries. Food waste in cities not only wastes resources but also brings environmental impacts, such as odor pollution and carbon emissions, and affects society economically and socially (Papargyropoulou, Wright, Lozano, Steinberger, Padfield & Ujang, 2016; Eriksson, Persson-Osowski, Malefors, Björkman & Eriksson, 2017; Samsuddin, Mastura-Zainal, Nurhanifah-Sulong & Faizal-Abu-Bakar, 2022; Liu, Hotta, Santo, Hengesbaugh, Watabe, Totoki et al., 2016; Nguyen-Trong, Nguyen-Thi-Ngoc, Nguyen-Ngoc & Dinh-Thi-Hai, 2017). Therefore, numerous countries prioritize reducing food waste in their development programs, especially in cities. However, in many cases, it is not economically feasible (van der Horst, Pascucci & Bol, 2014; van der Vorst, Beulens, Wit & van Beek, 1998), may bring social impacts, and require citizen awareness (Zhang, Huang & He, 2014).

The existence of food waste will have three general negative impacts (Janssen, Nijenhuis-de-Vries, Boer & Kremer, 2017). Firstly, food waste creates an unsightly aesthetic. Secondly, accumulating food waste is a nesting place for disease; apart from that, it also contains flies, cats, and mice, so that disease spreads quickly. Thirdly, food waste decomposes quickly and causes unpleasant odours and diseased waste. Based on the negative impacts outlined above, food waste requires proper management.

So far, the factors that influence the emergence of food waste that have been studied are analysed from the consumer or community side. These factors still need to be considered by local government policies and from the retail or restaurant side, for example, the environment (environmental performance, environmental management, and environmental conditions), nor do they touch on the sustainability process. So, it is possible that issues regarding the environment, both regional and global, are ignored or carried out unsustainably, which then leads to increasingly severe environmental damage.

Optimal handling is aimed at reducing the social, economic, and environmental impacts of accumulated food waste, which will later affect public health and the aesthetics of the city. For this reason, it is necessary to know the factors that trigger the emergence of food waste and the interrelationship between factors that influence the management of urban food waste (households, restaurants, supermarkets/markets). The factors used are from a more comprehensive perspective, involving aspects of suppliers, supermarket and restaurant managers/owners, sanitation services and practitioners to form a model that can describe the food waste phenomenon that occurs in urban areas.

The driving factors of food waste are multidimensional and interrelated (Thyberg & Tonjes, 2016; Schanes, Dobernig & Gözet, 2018). Understanding the complex relationships among these driving factors is crucial Ozgen-Genc and Ekici (2022) as it will enable food practitioners, governments, and policymakers to identify the root causes. As such, they can develop effective and sustainable strategies to reduce food waste. Developing countries such as Indonesia generate much food waste (United Nations Environment Programme, 2021). The sources of food waste in Indonesian cities include households, restaurants, and supermarkets or traditional markets. However, the contributions of each source have not been well-inspected or well-understood. Understanding the relationships among these drivers will be useful not only for formulating future policies but also for evaluating existing policies and initiatives and identifying any possible unintended outcomes. For example, reducing food waste by encouraging food donations to food banks may unintentionally encourage farmers to overproduce, hence increasing waste.

Previous studies examining the driving factors of food waste in households, hotels, and restaurants mainly use a systematic literature review and survey methods. For example, (Hebrok & Boks, 2017) and (Stangherlin & de Barcellos, 2018) identified food waste's main drivers and barriers using an extensive and systematic literature review. Meanwhile, research on the driving factors of household food waste has been extensive (Liegeard & Manning, 2020; Ilakovac, Iličković & Voća, 2018; Xu, Elomri, Pokharel, Zhang, Ming & Liu, 2017; Bernstad, 2014; Ko & Lu, 2020; Börühan & Ozbiltekin-Pala, 2021), followed by research on the driving factors of food waste in restaurants (Chalak, Abou-Daher, Chaaban & Abiad, 2016), food waste in service sectors (Wang, Liu, Liu, Liu, Gao, Zhou et al., 2017), hotels (Kasavan, Mohamed and Abdul-Halim, 2019), and retails (Belavina, Girotra & Kabra, 2017). It should be noted that previous studies have not examined the relationships among the driving factors of food waste in cities in more detail.

This study uses a combination of methods to identify the driving factors of food waste and develop a model of the relationships among the driving factors in Indonesian cities. The main contribution of this study is to fill the gap in the literature by proposing a model of the relationships among the driving factors of food waste. The model is based on the driving power and dependence power, estimated using the SIPOC framework using Interpretive Structural Modelling (ISM), and Matrice d'Impacts Croisés Multiplication Appliqué un Classement (MICMAC). The model is also based on the perspectives of food industry practitioners and academics. The results can be used by food industry practitioners and urban development policymakers to formulate effective food waste reduction programs. Academics can also understand the driving factors and their relationships to inform future research.

The remaining sections of this paper are organized as follows. Section 2 shows the literature review of relevant work. The methodology of research is presented in Section 3. The results of this study are described in section 4. The discussions, including managerial implications, are presented in Section 5. Finally, Section 6 presents conclusions and future research directions.

2. Literature Review

2.1. The Overview of Global Food Waste

Food waste is a major concern because it is directly related to public health, cleanliness, and aesthetics, especially in urban areas. Food waste is also a threat to food security as it may lead to hunger and malnutrition. Economic or direct losses caused by food waste are estimated at USD1 trillion per year (Salomone, Saija, Mondello, Giannetto, Fasulo & Savastano, 2016). Globally, the environmental costs caused by food waste are estimated at USD 700 billion, and social costs are USD 900 billion. As such, the total loss from food waste reaches USD 2.6 trillion annually, or 4% of the world's gross product (FAO, 2015). In the long term, food waste will cause environmental problems, hunger, and malnutrition, giving rise to more sustainability issues (Khalid, Naseer, Shahid, Mustafa-Shah, Irfan-Ullah, Waqar et al., 2019).

Food waste minimization efforts generally consist of prevention and utilization. For example, France and Germany require supermarkets to donate food to charities to minimize food waste. Supermarkets cannot throw away nearly spoiled fruit and vegetables and must sell them at a lower price (Papargyropoulou, Lozano, Steinberger, Wright & Ujang, 2014; Parfitt, Barthel & Macnaughton, 2010; Lozano-Miralles, Hermoso-Orzáez, Martínez-García & Rojas-Sola, 2018). Another example of utilization is food recycling. Food waste can be recycled to produce compost and turned into biogas using aerobic processes (Geislar, 2017; Tanguy, Villot, Glaus, Laforest & Hausler, 2017). In Europe, food waste is used by companies for generators. Food waste can also be used for animal feed (Mena, Terry, Williams & Ellram, 2014) for private farms or livestock in urban areas, which is processed through steaming.

Even though minimization has been carried out through prevention and utilization, food waste remains high. In England, in 2011, the amount of food waste from vegetables and fruits was around 1.3 billion tons per year. This figure equals one-third of the food produced for human consumption in developed countries, wasting around 1,500 calories per day per person. Meanwhile, in developing countries, around 400-500 calories per person are wasted daily. Forty percent of losses occur at retail and consumers, and another 40% occur after harvest and processing. The total food waste consumed in developed countries reaches 222 million tons (Abdelradi, 2018).

The definitions of food waste among institutions and organizations vary (Westendorf, 2000; Oreopoulou & Russ, 2007). Food waste can be seen from its type, how it is formed, and where it comes from (Dias-Ferreira, Santos & Oliveira, 2015). In poor and developing countries, most waste is generated in production and processing due to technical inefficiency. In developed countries, more food is wasted from consumption, with everyone wasting up to around 100 kg per year (Swaminathan, 2015).

This study defines food waste as any good-quality food eligible for human consumption but, for any reason, is not used for consumption. Food waste is generated at various points in the value chain, including distribution, sales in retail, food services, and consumption (Betz, Buchli, Göbel & Müller, 2015; Swaminathan, 2015). Since almost all players are in urban areas (Roodhuyzen, Luning, Fogliano & Steenbekkers, 2017; Parfitt et al., 2010), this study examines food waste in cities in Indonesia.

2.2. The Overview of Food Waste in Indonesian Cities

Food waste is a pressing problem in Indonesia because the Indonesian government does not handle it specifically, especially in urban areas. According to the Barilla Center for Food and Nutrition (2019), Indonesia ranked 24th (third lowest) in the world in food waste minimization and ranked the second largest in the world after Saudi Arabia in food waste generation (300 kg/person/year). The specific amount of urban food waste remains unknown because food waste from households, traditional markets, retail, and food services is combined with other types of waste.

The United Nations Environment Programme (UNEP) reported the amount of food waste in the 2021 Food Waste Index Report, with 17 countries' data being compatible with Sustainable Development Goals (SDGs) reporting. UNEP collects data through the United Nations Statistics Division (UNSD) in three sectors: food retails, households, and food services. From these data, Indonesia, represented by Surabaya, is included in the medium confidence category, as shown in Table 1.

Country	*Food waste* (kg/capita/year)	*Food waste* (tons/year)	Confidence in estimate
Brunei Darussalam	80	34.742	Very low confidence
Cambodia	86	1.423.397	Very low confidence
Indonesia	77	20.938.252	Medium confidence
Laos	86	618.994	Very low confidence
Malaysia	91	2.921.577	Medium confidence
Myanmar	86	4.666.125	Very low confidence
Philippines	86	9.334.477	Very low confidence
Singapura	80	465.385	Very low confidence
Thailand	79	5.478.532	Very low confidence
Timor-Leste	86	111.643	Very low confidence
Vietnam	76	7.346.717	Medium confidence

Table 1. The Amount of Food Waste in the Southeast Asia Region

In 2012, in Europe, the proportion of food waste from different sources was dominated by households. The data were obtained from the European Commission, as shown in Figure 1. Indonesia is represented by the city of Surabaya. Surabaya's total food waste generation, whose management is handled by the cleaning service, is 5,402.12 m^3/day. The largest waste generation is in southern Surabaya, at 26%. The amount of data for each Surabaya region is shown in Figure 2.

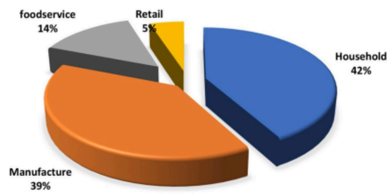

Figure 1. The Percentage of the Amount of Food Waste in Different Sources in Different Places (European Commission, 2012)

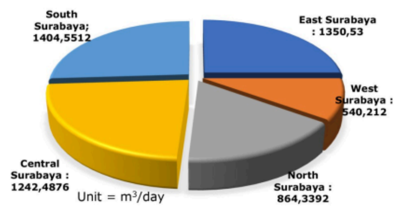

Figure 2. The Amount of Food Waste Generation in the Surabaya Area (DKRTH, 2017)

2.3. Urban Food Waste

The sources of food waste in city areas are identified by the places where it is formed or collected. Gelbert (1996) and Sastrawijaya (2000) argue that there are four sources of food waste. Firstly, residential food waste originates from households, governments, and private offices, such as the remains of food processing, leftover food, inedible food, cooking errors, and expired food. Secondly, trade food waste originates from trading areas, such as traditional markets, stalls, and supermarkets, as well as restaurants or canteens. Thirdly, agricultural and fishery food waste is generated during the harvest season, which is often burned or used for fertilizer. Finally, general food waste comes from the entire series of production processes.

Regarding the categories, according to the Sanitation and Green Open Space Service (DKRTH), waste is divided into two based on its nature: organic and inorganic waste. The former comes from living organisms, such as leaves and kitchen waste, and is degradable. The latter cannot be decomposed (non-degradable), such as rubber, plastic, cans, and metal. Food waste is organic waste (Indriartiningtias, Subagyo & Hartono, 2018).

The specific amount of urban food waste in Indonesia is not known for certain because food waste from households, traditional markets, retail, and food services is not separated. Mulyana, Gunawan and Tamara (2019) estimated the amount of food waste from food product stores in Surabaya. Brigita and Rahardyan (2013) examined the city of Bandung, Indonesia, involving seven restaurants as samples. The food waste generated was 0.23-2 liters/person/day, with a composition of 73% being food waste.

Maharrani and Syaifudin (2020) mentioned that Surabaya is the highest contributor to waste in Indonesia, comparable to other metropolitan cities in Indonesia, such as Central Jakarta, South Jakarta, Bandung, Depok, West

Jakarta, and Semarang. Table 2 shows the volume of waste produced by the population per day and the sources. Out of a total of 2800 tons of waste per day in the city of Surabaya, 43.5% came from households. Likewise, in other cities, the source of waste is dominated by households.

City	Total population (Million population)	Garbage amount (tons/days)	Source					
			Household (%)	Traditional market (%)	Trade center (%)	Office (%)	Public facility (%)	Other (%)
Surabaya	2,90	2,800	43,5	4,5	12,6	5,0	13,3	21,1
Central Jakarta	0,92	2,200	53	6,7	12,9	10,0	3,7	13,7
South Jakarta	2,20	1,600	87,6	12,4	0	0	0	0
Bandung	2,50	1,500	66	19,0	6,0	3,0	5,0	1
Makassar	1,50	1,400	63	3,0	13,4	8,5	1,1	11
Depok	2,30	1,300	62,7	9,3	7,5	1,9	4,6	14
West Jakarta	2,60	1,300	51	5,0	8,5	9,0	9,5	17
Semarang	1,80	1,300	70	5,0	5,0	2,0	3,0	15

Table 2. The Amount and Source of Waste in Eight Metropolitan Cities in Indonesia

2.4. The Driving Factors of Food Waste in Indonesian Cities

Literature reviews and in-depth interviews were conducted to identify and determine the factors driving food waste. A study by Attiq, Danish-Habib, Kaur, Shahid-Hasni and Dhir (2021) created a framework that brings together the factors causing waste generation to waste handling and waste reduction in the hospitality and food service (HaFS) sector. Other research related to the material driving food waste in households was conducted by Hebrok and Boks (2017), this research identified the factors that cause food waste on the consumer and socio-cultural side. In the reviewed literature, various aspects of consumer food waste were studied such as consumer behavior, attitudes, beliefs and values, quantification, and analysis of food waste composition in Western countries, waste prevention and concrete design interventions. The driving factors and obstacles in reducing food waste are categorized into social and personal factors as well as behavioral factors. Stangherlin and de Barcellos (2018) analyzes the main driving factors and obstacles to reducing food waste in the consumption phase and analyzes the path to anti-waste behavior. In other studies, e.g., Ryan-Fogarty, Becker, Moles and O'Regan (2017), Bosona and Gebresenbet (2013), and Morana, Squillaci, Paixao, Alves, La Cara and Moura (2017), the barriers were categorized for a more focused analysis. The current study uses the supplier-input-process-output-customer (SIPOC) framework to explore and categorize the driving factors as it focuses more on the driving factors at the operational level, as shown in Table 3.

2.5. Research Gaps

A study by Bees and Williams (2017) research, namely the separate collection of household food waste for recycling, this process contributes to reuse, recycling and composting in the UK and can help the UK government encourage landfill diversion. Abdelradi (2018) conducted a study of household consumer behavior towards food waste. An urban scale, research was carried out by Edwards, Othman, Burn and Crossin (2016), namely sustainable food waste collection and recycling framework for biogas fuel production in Hong Kong. The same thing was done by Laureri, Minciardi and Robba (2016), namely developing an approach to plan the collection of wet waste (food and other organic waste) on a metropolitan scale. Evaluation of the implementation of food waste collection in a case study restaurant in the coastal tourist area of Central Italy (Marche Region, Adriatic Seaside) was carried out by Tatàno, Caramiello, Paolini and Tripolone (2017) Examining food waste in retail (Irani et al., 2018). However, from several of these studies, the research areas for household, food service and retail were carried out separately, almost all of them conducted evaluation studies on food waste collection or provided suggestions on food waste collection percentages. There are still very few who have thoroughly researched the sources of urban food waste so that these factors can be used for preventive efforts to reduce food waste in urban areas.

From the summary of previous food waste in cities in Table 4, there is still no research found that models the relationships among the driving factors of food waste in three areas at once, namely households, markets/supermarkets, and restaurants in cities, especially in Indonesian cities. Previous papers reviewed were obtained from literature searches using the keywords (“food waste” AND “city” OR “household” OR “market” OR “supermarket” OR “restaurant” on the Scopus database. We found 20 related articles on Scopus database with the keywords used to search for the title, abstract and author’s keywords (see Table 4).

Driving Factor	Description	Reference
Supplier (S)		
S1. Inventory planning	The variety of fresh food products is high, with large quantities of supplies coming from various sources. These are to be redistributed or consumed for several days. The poor planning of food supplies can generate and increase food waste because food is not consumed or damaged due to long storage.	Balaji and Arshinder (2016), Marzouk and Azab (2014)
S2. Warehousing facilities	Suitable storage facilities (e.g., refrigerators, cold storage) are needed to store fresh perishable food products. Appropriate warehouse facilities can reduce damage.	Balaji and Arshinder (2016), Marzouk and Azab (2014), Schanes et al. (2018)
S3. Market access	Due to traffic jams, fresh food products distributed to several market areas, such as supermarkets and traditional markets, may be damaged if transportation takes a long time.	Marzouk and Azab (2014)
I. Input (I)		
I1. Food standards	Consumers concern too much about food safety and halalness, exceeding the rules set by BPOM and MUI. This results in end-consumers, restaurants, and supermarkets disposing of what should still be fit for consumption	Balaji and Arshinder (2016), Irani, Sharif, Lee, Aktas, Topaloğlu, Wout et al. (2018), Marzouk and Azab (2014), Schanes et al. (2018)
I2. Communication and collaboration	In buying and selling, miscommunication and miscoordination occur between supply chain actors (buyers and sellers). The fresh food products sent exceeded the quantity purchased, so there was a buildup of stock.	Irani et al. (2018)
I3. Demand fluctuation	Food or groceries may accumulate due to poor purchase planning; for example, food promotions or discounts may trigger more purchases, although the consumption capacity is the same. As a result, more food is damaged because it is stored too long.	Balaji and Arshinder (2016), Irani et al. (2018), Marzouk and Azab (2014), Schanes et al. (2018)
Process (P)		
P1. Processing methods and packaging designs	Food processing methods can help reduce food waste. If the taste is good and the price is reasonable, the demand will be high. By contrast, improper packaging design and methods can make food spoil faster.	Balaji and Arshinder (2016), Irani et al. (2018), Marzouk (2014), Expert opinion
P2. Cold storage and other facilities	Food’s shelf life will be longer if stored in coolers and display boxes. Lack of cold storage facilities and others can reduce food waste.	Balaji and Arshinder (2016), Marzouk and Azab (2014), Schanes et al. (2018)
P3. The portion of food sold/served	Ineffective food presentation and too much food being prepared, packaged, or served for sale may result in food waste. Food packed may not be suitable for consumer desires, or the portions may be too excessive, leading to more food waste.	Schanes et al. (2018), Expert opinion
P4. Workers’ knowledge and skills	Food workers need to have knowledge and skills regarding the quality of food products. A lack of understanding of the factors that cause food damage, such as food handling and stacking, can cause more food waste.	Schanes et al. (2018), Balaji and Arshinder (2016), Irani et al. (2018)

Driving Factor	Description	Reference
Output (O)		
O1. The distribution of usable food waste	Slightly damaged and leftover food is not distributed to people in need due to a lack of cooperation with food banks.	Expert opinion
O2. Information technology facilities	Food is wasted due to the lack of facilities and information technology to manage slightly damaged or leftover food and the lack of innovation for the collection.	Tromp, Haijema, Rijgersberg & van der Vorst (2016), Expert opinion
O3. Processing of leftover/slightly damaged food	Food waste is still eligible for consumption but is simply thrown away and not consumed. The reason is excessive concerns about food safety and disease that may arise from processing leftover or slightly spoiled food.	Schanes et al. (2018)
Customer (C)		
C1. Community attitude toward food waste	The culture of wasting food may be due to the desire to provide a variety of foods.	Schanes et al. (2018), Expert opinion
C2. Food waste disposal fee	Disposal fees for collecting and transporting food waste to the nearest collection center may lead to more food waste.	Tromp et al. (2016)

Table 3. The Driving Factors of Food Waste in Cities Based on the SIPOC Framework

No	Author(s), (year)	Objectives	City-Country	Scope	Method
1	Ağdağ (2009)	to investigate management system for food waste uncertainty in households	Denizli, Turkey	H	Exploratory study
2	Parizeau, von Massow and Martin (2015)	to identify the driver factors the increasing the amount of organic waste in household	Guelph, Ontario, Canada.	H	Survey, experiment
3	Edjabou, Petersen, Scheutz and Fruergaard-Astrup (2016)	to analysis the avoidable and unavoidable food waste in households	Denmark	H	Experiment
4	Delley and Brunner (2017)	to examine the attitudes perceptions and behavior of households	Swiss	H	Survey
5	Geislar (2017)	to develop model for predicting barriers of food waste collection in households	Costa Mesa, Southern California	H	Longitudinal and case study
6	Shearer, Gatersleben, Morse, Smyth and Hunt (2017)	to test the effectiveness The food waste collection using stickers in households.	United Kingdom	H	Survey
7	Hebrok and Boks (2017)	to identify the trigger factors of food waste to reduce food waste in households	Western countries	H	Literature review
8	Ponis, Papanikolaou, Katimertzoglou, Ntalla and Xenos (2017)	to investigate the effects of shopping habits and eating preferences in households	Yunani	H	Survey
9	Bees and Williams (2017)	to examine food shopping habits and awareness of the food waste in households	Candiff-Wales and Southampton -England.	H	Survey

No	Author(s), (year)	Objectives	City-Country	Scope	Method
10	Aschemann-Witzel, Otterbring, Hooge, Normann, Rohm, Almli et al. (2019)	to investigate food waste for household waste management	Netherlands, Sweden, Norway and Denmark. Jerman	M	Survey
11	Okumus (2020)	to identify the strategy food waste in hotels.	Orlando, Florida	Ho	Interview
12	Leverenz, Hafner, Moussawel, Kranert, Goossens and & Schmidt (2021)	to investigate food waste in hotels	Jerman	Ho	Case study
13	Wang et al. (2017)	to determine food waste in Chinese cities	Chengdu, Lhase, Shanghai, and Beijing - Tiongkok	R	Survey
14	Goh and Jie (2019)	to identify the employee motivation to reduce food waste in hotels.	None	Ho	Survey
15	Thamagasorn and Pharino (2019)	to analysis food waste in airline catering for food waste management	Thailand	R	Case study
16	Principato, Di-Leo, Mattia and Pratesi (2021)	to design food waste map to understand the phase of food waste and mitigation.	None	R	Literature review
17	Eriksson, Strid and Hansson (2016)	to reduce food waste in supermarkets using controlling cleanliness and storage temperatures	Swedia	M	Case study
18	Broekmeulen and van Donselaar (2019)	to measure the potential food waste, freshness, and perishable food in supermarkets	Eropa	M	Empirical data
19	Tomaszewska, Bilska, Tul-Krzyszczuk and Kołożyn-Krajewska (2021)	to examine the characteristics of food waste in restaurants	Polandia	R	In-depth (case study)
20	Reitemeier, Aheeyar and Drechsel (2021)	to identify perception of food waste reduction in markets and restaurants	Colombo - Sri Lanka	M, R	Interview
21	This research	to develop model relationships among the driving factors of food waste in Indonesian cities	Surabaya – Indonesia	H, M, R	ISM model

H = Households, M = Markets/Supermarket, R = Restaurant, Ho = Hotels

Table 4. The summarized previous research related to food waste in cites

3. Research Methodology

This study aims to identify the driving factors that trigger food waste production and analyze the hierarchical relationships between the driving factors. The Interpretative Structural Model (ISM) method is used in this study because it can identify the relationship between factors, determine the order and direction of complex relationships in a system, and analyze the effect of one factor on another (Malone, 1975). The ISM method is suitable for identifying the triggering factors for food waste based on expert justification. The reason is that the scope of the problem situation in this study is substantially broad, and the factors obtained from journal reviews are still debatable.

Surabaya City was chosen as the object of research in this study for several reasons. First. The amount of waste in Surabaya city (including wet waste (fruits, vegetables, etc.) is more (2,800 tons/days) than in Central Jakarta (2,200 tons/days), South Jakarta (1,600 tons/days) and Bandung (1,500 tons/days) (Maharrani & Syaifudin, 2020). In addition, Surabaya city as the main market for food products from East Java Province has high food waste. The largest food waste in Indonesia is believed to be in East Java province as the largest producer of fresh fruits and vegetables in Indonesia (Amirul, 2023). The Surabaya city government also has a food waste reduction program as one of the important programs in 2023-2024 (Pemkot-Surabaya, 2023).

The factors presented in this research are based on the literature review, which is corroborated by the opinion of experts in the food service industry (restaurant managers), retail managers, academics, and waste managers. The experts involved were 16 people. Experts are selected according to their field of knowledge and job responsibilities in accordance with the theme of this research. There are 6 practitioners, each of whom is an expert in fruit and vegetable supply and is responsible for restaurants and supermarkets in the waste section. 10 academics with more than 5 years of experience in the fields of food supply, food technology, and environmental ministry staff, as shown in Table 5.

No	Status	Work experience	Level of Education	Field	Job title
1	Practitioner	5 years	Undergraduate	Farmers Group Association	Corporate Secretary
2	Practitioner	5 years	Undergraduate	Vegetable supplier	Manager
3	Practitioner	10 years	Master	Fast food restaurant	Assistant Manager
4	Practitioner	16 years	Undergraduate	*Padang* restaurant	Owner
5	Practitioner	15 years	Undergraduate	Fruit and vegetable supermarket	Manager
6	Practitioner	5 years	Undergraduate	Fruit dan vegetable store	Manager
7	Academic	16 years	Doctor	Agro-industrial technology	Lecturer and researcher
8	Academic	10 years	Doctor	Agricultural industry information system	Lecturer and researcher
9	Academic	16 years	Doctor	Agro-industrial management	Lecturer and researcher
10	Academic	10 years	Master	Employees of the East Java Ministry of Environment	The field of socialization and waste management
11	Academic	5 years	Doctor	Food supply chain	Lecturer and researcher
12	Academic	10 years	Doctor	Food supply chain	Lecturer and researcher
13	Academic	10 years	Doctor	Food technology	Lecturer and researcher
14	Academic	16 years	Doctor	Food technology	Lecturer and researcher
15	Academic	16 years	Doctor	Agro-industrial management	Lecturer and researcher
16	Academic	5 years	Doctor	Food technology	Lecturer and researcher

Table 5. Expert Practitioners and Academics

4. Results

4.1. Data Collection Using the ISM Method

This stage uses an Interpretative Structural Model (ISM) approach, a group learning process where structural models are generated to portray a complex system through patterns with visuals and sentences. The factors at level 1 have the most significant influence.

The relationship between factors was identified using a pairwise comparison questionnaire derived with interview techniques. The questionnaire aimed to reach a consensus among experts without going through face-to-face meetings. When experts meet in person, they may interact and create social pressures that potentially cause bias (Einhorn, Hogarth, & Klempner, 1977). The interview was carried out in two stages. In the first stage, the experts were asked to complete a pairwise comparison questionnaire individually. In the second stage, they were given the opportunity to change their opinions or assessments after being shown the average value of the group's responses for each pairwise comparison in stage one. Experts who participated in this study were selected using sampling criteria by considering their areas of expertise, position, and experience.

4.2. Data Processing Using the ISM Method

ISM analyzes system elements and visually illustrates each direct relationship and its hierarchical level. The strength of system elements' relationships varies in triggering food waste, such as element (*i*) is a weak, moderate, strong, or very strong trigger of element (*j*). The steps of analysis using the ISM technique are as follows (Kanungo & Batnagar 2002):

Step 1: Designing research questionnaire (Table 6)

A system containing the element sets F= {*f*1, *f*2, ..., *fn*} is arranged in pairwise comparisons. The pairwise comparison scale is set at four levels, with 0 representing 'not a trigger,' 1 'a weak trigger,' 2 'a moderate trigger,' 3 'a strong trigger,' and 4 'a very strong trigger.' Then the experts were asked to fill in pairwise comparisons from element *fi* to element *fj* using the four-level scores based on their beliefs. An example of a completed questionnaire can be seen in Table 6.

Opinions					
No	Weak	Currently	Strong	Very strong	Y (Driver factors)
	X				Warehousing facilities (S2)
			X		Market entry access (S3)
	X				Food standard (I1)
				X	Communication and collaboration (I2)
				X	Demand fluctuations (I3)
		X			Processing method and packaging design (P1)
	X				Cold storage and other facilities (P2)
X					The portion of food sold/served (P3)
			X		Workers' knowledge and skills (P4)
		X			The distribution of usable food waste (O1)
				X	Information technology facilities (O2)
				X	Processing of leftover/slightly damaged food (O3)
			X		Community attitude toward food waste (C1)
		X			Cost of using food waste (C2)

Inventory planning (S1) has the effect of triggering the occurrence of food waste (X) on (Y)

Table 6. An example of a completed questionnaire

Step 2: Building Initial Direct Relation Matrix (A)

There are H (16) experts and a few elements to consider when constructing the Initial Direct-Relations Matrix. Each expert will generate n x n matrix non-negative $X^4 = \{X_{ij}^4\}_{nxn}$, with $1 \le k \le H$. Then, the nxn mean matrix, which accommodates all the expert opinions, is calculated by taking the average of their scores using Equation 1.

$$A = \left[Q_{ij}\right]_{n\,x\,n} = \frac{1}{H}\sum_{k=1}^{M}\left[X_{i,j}{}^{4}\right]_{n\,x\,n} \tag{1}$$

The average matrix A, hereinafter referred to as the Initial Direct-Relation Matrix, shows the direct influence of each element given and received from other elements. The results of the initial direct-relation matrix are shown in Table 7.

f	S1	S2	S3	11	12	13	P1	P2	P3	P4	O1	O2	O3	C1	C2	Σ
S1	4	2,214	1,000	0,143	1,714	0,500	0,286	2,214	0,000	0,357	0,500	0,429	0,429	0,571	3,143	10,357
S2	3,429	4	2,500	3,143	0,429	0,500	0,429	3,643	0,571	0,429	0,214	0,429	1,000	0,214	0,429	20,929
S3	0,500	3,143	4	3,357	1,000	0,571	2,786	3,000	0,143	0,429	0,214	0,429	0,214	0,143	0,714	19,929
11	0,500	3,643	0,429	4	0,429	0,429	3,571	3,571	0,286	2,929	0,214	3,214	2,714	0,214	0,286	26,143
12	3,143	0,286	3,000	3,000	4	0,357	0,143	0,071	0,143	2,929	3,000	3,429	0,143	3,000	0,143	26,643
13	3,643	2,929	0,429	0,429	3,214	4	0,071	2,929	0,143	0,500	2,786	0,429	3,571	0,071	3,571	25,143
P1	3,500	3,571	0,571	3,571	0,286	2,714	4	3,714	2,857	0,214	0,143	0,500	0,143	0,143	2,643	25,929
P2	3,500	1,429	0,214	0,357	1,929	0,143	3,429	4	0,143	2,500	2,786	3,786	0,286	0,286	2,643	24,786
P3	3,214	2,643	0,429	1,571	0,571	3,071	3,500	2,714	4	0,143	0,214	0,500	0,214	0,286	2,786	23,071
P4	3,143	2,714	0,357	3,857	3,429	0,286	3,929	3,071	0,357	4	3,000	4,000	0,214	0,143	0,143	32,500
O1	0,357	0,214	0,429	0,357	3,643	2,929	3,643	3,643	0,143	0,143	4	0,500	0,214	3,786	3,571	24,000
O2	3,929	3,643	0,500	3,500	3,857	3,143	3,500	3,429	0,143	3,857	0,286	4	0,429	0,214	0,143	34,429
O3	0,500	0,500	0,357	0,214	0,429	0,143	2,786	0,214	0,143	0,429	3,571	0,357	4	3,357	3,643	17,000
C1	2,429	0,357	0,143	2,714	0,143	0,214	0,714	0,071	3,857	0,357	3,571	0,429	3,500	4	2,571	22,500
C2	3,643	1,429	0,500	0,214	0,286	0,143	3,714	3,357	2,357	0,429	3,429	0,643	3,286	3,286	4	26,714
Σ	39,429	32,714	14,857	30,429	25,357	19,143	36,500	39,643	15,286	19,643	27,929	23,071	20,357	19,714	30,429	

Table 7. The initial direct-relation matrix

Step 3: Converting the Initial Direct-Relation Matrix (A) to the Normalized Direct-Relation Matrix (G)

The score scale used may vary across studies. Therefore, the Initial Direct-Relation Matrix needs to be converted to a Normalized Direct-Relation Matrix G = $[g_{ij}]_{n \times n}$ with $0 \leq g_{ij} \leq 1$. The normalization result is presented in Table 8.

$$G = \frac{1}{max \sum_{j=1}^{n} g_{ij}} A \quad i,j = 1, \ldots, n \tag{2}$$

f	S1	S2	S3	11	12	13	P1	P2	P3	P4	O1	O2	O3	C1	C2
S1	0,101	0,056	0,025	0,004	0,043	0,013	0,007	0,056	0,000	0,009	0,013	0,011	0,011	0,014	0,079
S2	0,086	0,101	0,063	0,079	0,011	0,013	0,011	0,092	0,014	0,011	0,005	0,011	0,025	0,005	0,011
S3	0,013	0,079	0,101	0,085	0,025	0,014	0,070	0,076	0,004	0,011	0,005	0,011	0,005	0,004	0,018
11	0,013	0,092	0,011	0,101	0,011	0,011	0,090	0,090	0,007	0,074	0,005	0,081	0,068	0,005	0,007
12	0,079	0,007	0,076	0,076	0,101	0,009	0,004	0,002	0,004	0,074	0,076	0,086	0,004	0,076	0,004
13	0,092	0,074	0,011	0,011	0,081	0,101	0,002	0,074	0,004	0,013	0,070	0,011	0,090	0,002	0,090
P1	0,088	0,090	0,014	0,090	0,007	0,068	0,101	0,094	0,072	0,005	0,004	0,013	0,004	0,004	0,067
P2	0,088	0,036	0,005	0,009	0,049	0,004	0,086	0,101	0,004	0,063	0,070	0,095	0,007	0,007	0,067
P3	0,081	0,067	0,011	0,040	0,014	0,077	0,088	0,068	0,101	0,004	0,005	0,013	0,005	0,007	0,070
P4	0,079	0,068	0,009	0,097	0,086	0,007	0,099	0,077	0,009	0,101	0,076	0,101	0,005	0,004	0,004
O1	0,009	0,005	0,011	0,009	0,092	0,074	0,092	0,092	0,004	0,004	0,101	0,013	0,005	0,095	0,090
O2	0,099	0,092	0,013	0,088	0,097	0,079	0,088	0,086	0,004	0,097	0,007	0,101	0,011	0,005	0,004
O3	0,013	0,013	0,009	0,005	0,011	0,004	0,070	0,005	0,004	0,011	0,090	0,009	0,101	0,085	0,092
C1	0,061	0,009	0,004	0,068	0,004	0,005	0,018	0,002	0,097	0,009	0,090	0,011	0,088	0,101	0,065
C2	0,092	0,036	0,013	0,005	0,007	0,004	0,094	0,085	0,059	0,011	0,086	0,016	0,083	0,083	0,101

Table 8. Normalized Direct-Relation Matrix (G)

Step 4: Calculating the Total-Relation Matrix (T)

Total-Relation Matrix T = $\{t_{ij}^{4}\}_{nxn}$ is obtained using Equation 3, where l is the identity matrix. The total calculation results are shown in Table 9.

$$T = G(1\text{-}G)^{-1} \quad (3)$$

f	S1	S2	S3	11	12	13	P1	P2	P3	P4	O1	O2	O3	C1	C2
S1	0,193	0,122	0,058	0,057	0,094	0,042	0,076	0,142	0,027	0,047	0,070	0,058	0,049	0,056	0,148
S2	0,188	0,191	0,105	0,154	0,067	0,048	0,098	0,202	0,041	0,061	0,062	0,073	0,069	0,041	0,081
S3	0,112	0,174	0,145	0,169	0,080	0,054	0,165	0,190	0,034	0,063	0,060	0,074	0,047	0,037	0,085
11	0,153	0,217	0,056	0,213	0,093	0,069	0,223	0,240	0,049	0,154	0,087	0,176	0,129	0,055	0,100
12	0,213	0,117	0,130	0,188	0,198	0,067	0,123	0,136	0,044	0,154	0,167	0,179	0,061	0,142	0,093
13	0,237	0,177	0,062	0,094	0,173	0,161	0,118	0,213	0,045	0,075	0,180	0,087	0,165	0,080	0,211
P1	0,242	0,218	0,062	0,189	0,084	0,133	0,228	0,251	0,125	0,069	0,085	0,092	0,069	0,055	0,180
P2	0,246	0,154	0,053	0,112	0,147	0,068	0,222	0,256	0,050	0,142	0,166	0,191	0,062	0,071	0,176
P3	0,223	0,179	0,054	0,124	0,085	0,140	0,202	0,208	0,154	0,057	0,082	0,080	0,065	0,057	0,178
P4	0,258	0,217	0,070	0,236	0,205	0,084	0,258	0,261	0,058	0,203	0,181	0,222	0,069	0,071	0,117
O1	0,157	0,108	0,057	0,104	0,184	0,142	0,220	0,236	0,063	0,068	0,215	0,093	0,078	0,180	0,214
O2	0,292	0,251	0,079	0,231	0,220	0,158	0,243	0,275	0,052	0,203	0,115	0,225	0,084	0,070	0,122
O3	0,110	0,083	0,038	0,ü70	0,065	0,049	0,170	0,104	0,052	0,047	0,176	0,055	0,163	0,157	0,190
C1	0,178	0,098	0,037	0,147	0,067	0,061	0,133	0,120	0,156	0,056	0,181	0,069	0,159	0,176	0,176
C2	0,248	0,149	0,058	0,099	0,089	0,070	0,236	0,238	0,127	0,069	0,197	0,091	0,159	0,168	0,239

Table 9. Total-Relation Matrix (T)

Step 5: Converting the Total-Relation Matrix (T) to the Initial Reachability Matrix (K)

The T matrix represents the relationship between the observed elements. The element f_i is considered to affect the element f_j if t_{ij} is greater than the threshold value. Threshold value (a) is the average value of t_{ij} in the Total-Relation Matrix. The Initial Reachability Matrix (K) is used to show the relationship from element f_j to element f_i expressed in binary number {0,1}. Therefore, the conversion of matrix T to matrix K is shown in Equation 4. Changes in the value of the Initial Reachability Matrix (K) are shown in Table 10.

$$k_{ij} = 0 \; if \; t_{ij} < a, else \; k_{ij} = 1 \quad i, j = 1, \dots, n \tag{4}$$

f	S1	S2	S3	11	12	13	P1	P2	P3	P4	O1	O2	O3	C1	C2
S1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1
S2	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0
S3	0	1	1	1	0	0	1	1	0	0	0	0	0	0	0
11	1	1	0	1	0	0	1	1	0	1	0	1	0	0	0
12	1	0	1	1	1	0	0	1	0	1	1	1	0	1	0
13	1	1	0	0	1	1	0	1	0	0	1	0	1	0	1
P1	1	1	0	1	0	1	1	1	0	0	0	0	0	0	1
P2	1	1	0	0	1	0	1	1	0	1	1	1	0	0	1
P3	1	1	0	0	0	1	1	1	1	0	0	0	0	0	1
P4	1	1	0	1	1	0	1	1	0	1	1	1	0	0	0
O1	1	0	0	0	1	1	1	1	0	0	1	0	0	1	1
O2	1	1	0	1	1	1	1	1	0	1	0	1	0	0	0
O3	0	0	0	0	0	0	1	0	0	0	1	0	1	1	1
C1	1	0	0	1	0	0	1	0	1	0	1	0	1	1	1
C2	1	1	0	0	0	0	1	1	0	0	1	0	1	1	1

Table 10. Initial Reachability Matrix (K)

Step 6: Checking the transitivity and defining the Final Reachability Matrix (K')

According to Simpson and Simpson (2014), transitivity is needed to ensure the consistency of the relationship between elements. As such, mediation can occur between empirical data and mathematical logic in system development. In the ISM procedure, this transitivity is explained as follows: if f_1 is related to f_2 and f_2 is related to f_3, then f_1 is related to f_3, so $k_{13} = 1$. After all, $k_{ij} = 0$ are checked for transitivity, the Final Reachability Matrix (K') is formed, shown in Table 11.

f	S1	S2	S3	11	12	13	P1	P2	P3	P4	O1	O2	O3	C1	C2
S1	1	1	0	0	1	0	1	1	0	1	1	1	0	0	1
S2	1	1	0	1	1	0	1	1	0	1	1	1	0	0	1
S3	0	1	1	1	0	1	1	1	1	0	0	0	0	0	1
11	1	1	1	1	1	0	1	1	0	1	1	1	1	0	1
12	1	0	1	1	1	0	1	1	0	1	1	1	0	1	1
13	1	1	0	0	1	1	1	1	0	1	1	1	1	0	1
P1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
P2	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
P3	1	1	0	0	0	1	1	1	1	0	1	0	1	1	1
P4	1	1	0	1	1	1	1	1	1	1	1	1	0	0	1
O1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1
O2	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
O3	0	0	1	1	1	1	1	0	1	1	1	1	1	1	1
C1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1
C2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 11. Final Reachability Matrix (K')

Step 7: Determining the reachability and the antecedent sets

Poduval, Pramod and Jagathy-Raj (2015) states that a reachability set is defined as a set of elements reached by certain elements. Meanwhile, an antecedent set is defined as a set of elements needed to reach certain elements. Technically, a reachability set (RSi) of system elements is a set of elements corresponding to the column where all the elements in row i of the Final Reachability Matrix are 1 (Equation 5). An antecedent set (ASI) of the system elements is a set of elements corresponding to the row where all the elements in column i of the Final Reachability Matrix are 1 (Equation 6). The results of the D + R and D-R sets are shown in Table 12.

$$RS_i = \{f_i | j \in (1, \dots, n), k_{ij} \neq 0\}, \quad (i = 1,2, \dots, n) \tag{5}$$

$$AS_i = \{f_j | j \in (1, \dots, n), k_{ji} \neq 0\}, \quad (i = 1,2, \dots, n) \tag{6}$$

No	D+R		D-R	
	Code	Score	Code	Score
1	**P2**	5,189525	**P4**	1,040632
2	**P1**	4,797041	**O2**	0,856279
3	**C2**	4,545733	**P3**	0,814166
4	**O2**	4,383188	**I3**	0,731273
5	**S1**	4,288488	**S3**	0,426692
6	**I1**	4,201009	**C1**	0,397364
7	**O1**	4,142575	**I2**	0,161960
8	**P4**	3,978329	**O3**	0,099900
9	**S2**	3,936363	**O1**	0,094698
10	**I2**	3,863308	**C2**	-0,074510
11	**I3**	3,420994	**I1**	-0,173850
12	**C1**	3,228746	**P1**	-0,631260
13	**P3**	2,962795	**P2**	-0,955280
14	**O3**	2,955928	**S2**	-0,975420
15	**S3**	2,554695	**S1**	-1,812640

Table 12. The dispatcher and receiver sets

D is the dispatcher, and R is the receiver. D + R indicates the rank. The highest-ranked factor is cold storage and other facilities (P2). Meanwhile, D – R shows the strength of influence and being influenced. The result is the knowledge and skill factor (P4).

Step 8: Building a Hierarchical Structure

Elements that appear both in the reachability and antecedent sets are selected as hierarchical set. With this, the set equation can be written as Equation 7.

$$IS_i = RS_i \cap AS_i \quad (7)$$

The arrangement of elements starts from level 1, placed at the top of the hierarchy. The selected elements have the same reachability set as the intersection set in the Final Reachability Matrix (K'). For the next iteration, elements that have entered level-i are removed from the Final Reachability Matrix (K'). The process is repeated from the beginning until the level of all elements is found. The results of the level calculation are shown in Table 13.

Iterasi	Elemen	Himpunan Reachbility	Himpunan Antedecent	Irisan	Level
1	S1	1,4,6,7,8,10,11,12,15	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	1,4,6,7,8,10,11,12,15	1
1	S2	1,2,4,5,7,8,9,10,11,12,15	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	1,2,4,5,7,8,9,10,11,12,15	1
1	I2	1,2,3,4,5,7,8,10,11,12,14,15	1,2,4,5,6,7,8,10,11,12,13,14,15	1,2,3,4,5,7,8,10,11,12,14,15	1
1	I3	1,2,5,6,7,8,10,11,12,13,15	3,6,7,8,9,10,11,12,13,14,15	1,2,5,6,7,8,10,11,12,13,15	1
1	P1	1,2,4,5,6,7,8,9,10,11,12,15	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	1,2,4,5,6,7,8,9,10,11,12,15	1
1	P2	1,2,3,4,5,6,7,8,9,10,11,12,15	1,2,3,4,5,6,7,8,9,10,11,12,15	1,2,3,4,5,6,7,8,9,10,11,12,15	1
1	P4	1,2,4,5,6,7,8,9,10,11,12,15	1,2,4,5,6,7,8,10,11,12,13,14,15	1,2,4,5,6,7,8,9,10,11,12,15	1
1	O2	1,2,3,4,5,6,7,8,9,10,11,12,15	1,2,4,5,6,7,8,10,11,12,13,14,15	1,2,4,5,6,7,8,10,11,12,13,14,15	1
1	C2	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	1
2	S3	4,11,13	3,4,11,13,14	4,11,13	2
2	I1	9,11,13,14	3,9,11,13,14	9,11,13,14	2
3	S3	3	3,11,13,14	3	3
4	O1	11,14	11,13,14	11,14	4
4	C1	11,13,14	11,13,14	11,13,14	4
5	O3	1	1	1	5

Table 13. Partitioning Levels

Step 9: Creating the Diagram

The element levels and the Final Reachability Matrix are used to draw the directional graph—a visualization of elements, contextual relationships between elements, and hierarchical levels. The graphical model is generated using matrices or nodes. The relationships between the elements in the Initial Reachability Matrix are preceded by arrows, as shown in Figure 3.

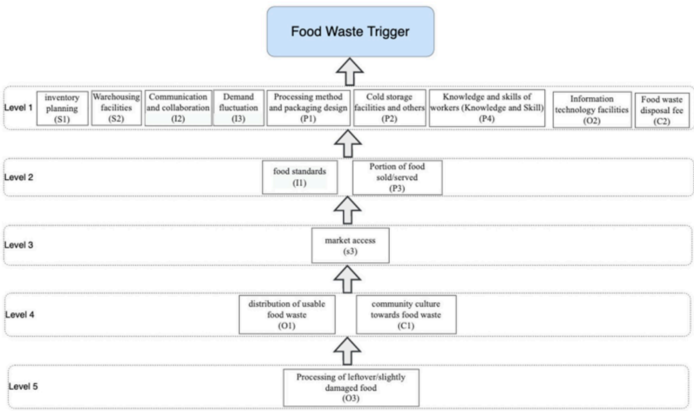

Figure 3. The Hierarchical Model

Step 10: Generate MIC-MAC Cartesian Diagram

The MICMAC Cartesian diagram is used to classify the identified elements into four groups: autonomous, dependent, linkage, and independent. Cluster I, autonomous, consists of elements with weak driving power and dependency. Cluster II, dependent, consists of elements with weak driving power but strong dependency. Cluster III, linkage, consists of elements with strong driving power and dependency. Finally, cluster IV, independent, consists of elements with strong driving power and weak dependency. The basic ingredients of a system are system components, the relationships between these components, system behavior or activities or system transformation processes, system environment, system input from the system environment, system output to the system environment, and the special interests of the system observers. The grouping of MICMAC results is shown in Figure 4.

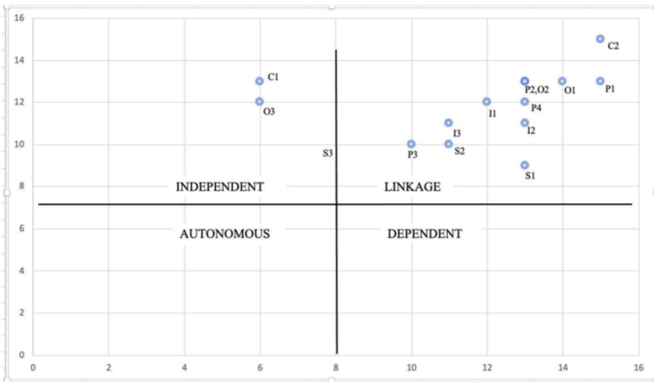

Figure 4. MICMAC diagram

Nine driving factors of the food waste at the top of the ISM hierarchy at level 1 (see Figure 3) such as S1 (inventory planning), S2 (warehouse facilities), I2 (communication and collaboration), I3 (demand fluctuations), P2 (cold storage facilities), P1 (processing method and packaging design), P4 (knowledge and skills of workers), O2 (information technology facilities), C2 (food waste disposal fee). These nine driving factors show that more than 60% of the driving factors are at the top of the hierarchy and directly influence the drivers for food waste. The MICMAC results also include these nine driving factors in the linkage cluster (Figure 4). This indicates that the nine driving factors that drive food waste influence each other. These findings support the research position that the factors driving food waste have also been stated by Balaji and Arshinder (2016), Marzouk and Azab (2014), Schanes et al. (2018), Irani et al. (2018), Tromp et al. (2016). Therefore, these nine driving factors have also been identified as having a direct influence on driving food waste. At the same time, the other six driving factors are also divided into levels 2,3, 4 and 5.

There is 1 factor at level 5, namely O3 (processing of leftover/slightly damaged food). This is a very significant factor because it influences all the other factors that trigger food waste above it. Factor O3 in the MICMAC image occupies an independent group where this factor actively influences other factors but is not influenced by other factors. Schanes et al. (2018) stated that food waste is still suitable for consumption but is simply thrown away and not consumed. The cause is excessive concern about food safety and diseases that may arise from processing leftover or slightly stale food. Therefore, this factor must be managed well. It is hoped that there will be a significant reduction in the amount of food waste in households, supermarkets, and restaurants by managing this factor.

5. Discussions

Food waste continued to increase annually at 23-48 million tons/year from 2000 to 2019 (Bappenas, 2021). This amount equals 115-184 kg/year/person or economic losses of IDR 213-551 trillion (4-5% of Gross Domestic Product), which could feed 61-125 million people or 29-47% of Indonesia's population. According to Rizanty (2022), vegetables are the most discarded type of food, at 31%, followed by rice at 20%, meat at 11%, dairy products at 10%, and fish at 10%. The environmental impact of this food waste is the accumulation of greenhouse gases in the atmosphere: 50-55% methane and 40-45% CO2. Despite the high amount of food waste per year, the economic welfare of the Indonesian people does not increase. The 2021 Global Hunger Index ranked Indonesia's hunger in the third place in Southeast Asia. The index score was 18 points, categorized as moderate and above the global average of 17.9 points.

For this reason, knowing the driving factors of food waste generation is crucial. This study combined the driving factors for food waste observed in previous studies. In a preliminary study, we conducted interviews and captured additional driving factors for food waste generation. We classify these factors using the SIPOC concept. The results show 15 driving factors for food waste along the supply chain were identified using the ISM method.

The results of the MICMAC diagram in Figure 4 show that the independent factors are O3 (Processing leftover/slightly damaged food), C1 (Community attitude toward food waste), and S3 (Access to market entry). The calculation results of the dispatcher set, and the receiver set for DR (influencing factors) show that the three factors are positive, which means they have a strong influence. Meanwhile, the ISM results (Figure 3) show that O3 is at level 5, C1 is at level 4, and S3 is at level 3. The findings are confirmed in the interviews conducted with supermarket managers and academics.

The driving factors of food waste at consumers' tables include the habit of taking excessive portions. When a portion of food taken exceeds the needs and capacity, it is likely to be wasted. This habit must change immediately, and consumers must learn how to measure their needs appropriately. Leftovers can be stored for later use, but unfinished food may not be suitable for next consumption. In other words, minimizing food waste begins with managing self-control when taking a portion of food.

Table 12 shows that a positive D-R value is a causal factor, and a positive D-R value is an effect factor. The driving factors of food waste with a strong influence are shown by the positive R-D values in Table 12 and the MICMAC results that fall under the independent quadrant (see Figure 4), namely factor O3 (treatment of remaining food), C1 (community attitude toward food waste), S3 (market entry access). The factors with positive D-R values (influential) and at level 1 in the ISM figure (see Figure 3) are S1 (inventory planning), S2 (warehouse facilities), I2 (collaboration), I3 (demand fluctuations), P1 (processing method), P2 (display facilities, P4 (food portions), O2 (utilization of information technology), and C2 (utilization of leftovers). These factors directly cause food waste.

By 2050, the world is predicted to need around 60% more calories per year to feed the projected 9 billion more people (Bahar, Lo, Sanjaya, Van Vianen, Alexander, Ickowitz & Sunderland, 2020). Reducing global food waste can help close the gap while improving the environment and the economy. According to the expert participants in this study (restaurant managers), minimizing food waste can start in households, such as paying attention to the expiration date of the packed food stored at home so food wasted due to expiration can be avoided. The employees of the East Java Ministry of Environment also stated the importance of managing food storage to reduce food waste. Food stored properly will not spoil quickly.

Another way to avoid food waste in households is by giving away or sharing excess food with nearby people, such as friends, family, neighbors, or other relatives. This solution will not only reduce food waste but also foster social cohesion. This should be coupled with good storage management. For example, Ogunranti and Oluleye (2016) propose five steps to avoid food waste at home. The first is to make a food menu plan before shopping to avoid impulsive grocery shopping. The second is to apply the first in, first out (FIFO) principle, such as by preparing meals based on the food supply that has been stored the longest. The third is to buy ingredients that can be consumed immediately and stored in the freezer for a short time, which is then consumed using the FIFO principle. The fourth is to store food ingredients properly to last longer. The last is to put perishable food ingredients in a visible place.

6. Conclusions

The research results can be used by the policymakers in the decision-making on food-related policies and advise industries, businesses, and households to take preventive actions to avoid food waste. This research provides insights into the driving factors that are the most dominant in the generation of food waste and shows the important relationship between these factors. Further research should cover not only businesses such as supermarkets and restaurants but also other organizations. This study prioritizes two stakeholders to determine the driving factors of food waste. Other stakeholders to be involved include government regulators and NGOs. The more stakeholders involved, the more comprehensive the driving factors of food waste that can be captured. Identification of proposed drivers of food waste can provide information to municipal governments on how to manage food waste. These findings can also help households, restaurants, and markets/supermarkets in Indonesia in minimizing food waste. The hierarchical structure of the ISM approach allows practitioners to better identify the goals of reducing food waste in Indonesian cities.

By knowing the factors that influence the emergence of food waste, we can formulate the development of food waste management models in cities to formulate comprehensive policies in order to minimize environmental, social and economic impacts, so sustainable environmental indicators need to be developed (Hebrok & Boks, 2017) According to Irani et al. (2018) food regulatory standards, organizing and planning food supply, food quality management, increasing food and packaging recycling, bureaucracy, investment, incentives, working with local charities. So, combining the factors that cause food waste from the consumer and food service side can be used as a consideration for developing policies for stakeholders, namely the government (food waste managers) and food service.

The driving factors of food waste in cities include processing leftovers or slightly damaged food, the distribution of usable food waste, and the community's attitude toward food waste. The practical implication of this finding is that those driving factors must be incorporated into the guidelines for food waste players, including city governments. The relationship model can help manage driver factors of food waste in Indonesian households, restaurants, and markets/supermarkets. In addition, the ISM hierarchical structure allows practitioners to better identify the objectives of food waste reduction in Indonesian cities. The findings can also be disseminated to society to help them better understand the driving factors of food waste in cities. Minimizing food waste will lead to higher food security and, eventually, better welfare.

The limitation of this study relates to the theory and implementation. This study identifies the driving factors of food waste from literature, which may not be comprehensive. Future studies should undertake a systematic review to gather and corroborate other factors using expert opinion. Lastly, this study focuses on the driving factors in Indonesian cities, particularly Surabaya, which may affect the generalizability. Future studies could extend the scope by involving other cities such as Jakarta, Bandung, and Medan. Assessing other cities and comparing the results will yield a more rigorous result and accurately capture the relationship driving factors of food waste.

Declaration of Conflicting Interests

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References

Abdelradi, F. (2018). Food waste behaviour at the household level: A conceptual framework, *Waste Management*, 71, 485-493. https://doi.org/10.1016/j.wasman.2017.10.001

Ağdağ, O.N. (2009). Comparison of old and new municipal solid waste management systems in Denizli, Turkey. *Waste Management*, 29(1), 456–464. https://doi.org/10.1016/j.wasman.2008.01.012

Amirul (2023). *7 Daerah Penghasil Sayuran Terbesar di Indonesia.* Available at: https://www.limakilo.id/7-daerah-penghasil-sayuran-terbesar-di-indonesia/

Aschemann-Witzel, J., Otterbring, T., Hooge, I.E., Normann, A., Rohm, H., Almli, V.L. et al. (2019). The who, where and why of choosing suboptimal foods: Consequences for tackling food waste in store. *Journal of Cleaner Production*, 236. https://doi.org/10.1016/j.jclepro.2019.07.071

Attiq, S., Danish-Habib, M., Kaur, P., Shahid-Hasni, M.J., & Dhir, A. (2021). Drivers of food waste reduction behaviour in the household context. *Food Quality and Preference*, 94, 104300. https://doi.org/10.1016/j.foodqual.2021.104300

Bahar, N.H.A., Lo, M., Sanjaya, M., Van Vianen, J., Alexander, P., Ickowitz, A., & Sunderland, T.. (2020) Meeting the food security challenge for nine billion people in 2050: What impact on forests? *Global Environmental Change*, 62(May), p. 102056. https://doi.org/10.1016/j.gloenvcha.2020.102056

Balaji, M., & Arshinder, K. (2016). Modeling the causes of food wastage in Indian perishable food supply chain. *Resources, Conservation and Recycling*, 114, 153-167. https://doi.org/10.1016/j.resconrec.2016.07.016

Bappenas. (2021). *Bappenas Paparkan Pentingnya Pengelolaan 'Food Loss and Waste'*. https://www.infopublik.id/kategori/nasional-ekonomi-bisnis/539725/index.html

Barilla Center for Food and Nutrition (2019). *"Food waste", Healthy and Sustainable Food Systems, 2019*. books.google.com. Available at: https://www.barillagroup.com

Bees, A.D., & Williams, I.D. (2017). Explaining the differences in household food waste collection and treatment provisions between local authorities in England and Wales. *Waste Management*, 70, 222-235. https://doi.org/10.1016/j.wasman.2017.09.004

Belavina, E., Girotra, K., & Kabra, A. (2017). Online grocery retail: Revenue models and environmental impact. *Management Science*, 63(6), 1781-1799. https://doi.org/10.1287/mnsc.2016.2430

Bernstad, A. (2014). Household food waste separation behavior and the importance of convenience. *Waste Management*, 34(7), 1317-1323. https://doi.org/10.1016/j.wasman.2014.03.013

Betz, A., Buchli, J., Göbel, C., & Müller, C. (2015). Food waste in the Swiss food service industry – Magnitude and potential for reduction. *Waste Management*, 35, 218-226. https://doi.org/10.1016/j.wasman.2014.09.015

Börühan, G., & Ozbiltekin-Pala, M. (2021). Food waste management: an example from university refectory. *British Food Journal*, 124(1), 293-313. https://doi.org/10.1108/BFJ-09-2020-0802

Bosona, T., & Gebresenbet, G. (2013). Food traceability as an integral part of logistics management in food and agricultural supply chain. *Food Control*, 33(1), 32-48. https://doi.org/10.1016/j.foodcont.2013.02.004

Brigita, G., & Rahardyan, B. (2013) Analisa Pengelolaan Sampah Makanan Di Kota Bandung. *Jurnal Tehnik Lingkungan*, 19(1), 34-45. Available at: https://doi.org/10.5614/jtl.2013.19.1.4

Broekmeulen, R.A.C.M., & van Donselaar, K.H. (2019). Quantifying the potential to improve on food waste, freshness and sales for perishables in supermarkets. *International Journal of Production Economics*, 209(July), 265-273. https://doi.org/10.1016/j.ijpe.2017.10.003

Chalak, A., Abou-Daher, C., Chaaban, J., & Abiad, M.G. (2016). The global economic and regulatory determinants of household food waste generation: A cross-country analysis. *Waste Management*, 48, 418-422. https://doi.org/10.1016/j.wasman.2015.11.040

Delley, M., & Brunner, T.A. (2017). Foodwaste within Swiss households: A segmentation of the population and suggestions for preventive measures. *Resources, Conservation and Recycling*, 122(December 2012), 172-184. https://doi.org/10.1016/j.resconrec.2017.02.008

Dias-Ferreira, C., Santos, T., & Oliveira, V. (2015). Hospital food waste and environmental and economic indicators – A Portuguese case study. *Waste Management*, 46, 146-154. https://doi.org/10.1016/j.wasman.2015.09.025

DKRTH (2017). *Profil Dinas Kebersihan dan Ruang Terbuka Hijau Kota Surabaya Tahun 2017*. Surabaya: Dinas Kebersihan dan Ruang Terbuka Hijau Kota Surabaya. https://www.surabaya.go.id/id/page/0/8079/dinas-kebersihan-dan-pertamanan

Edjabou, M.E., Petersen, C., Scheutz, C., & Fruergaard-Astrup, T. (2016). Food waste from Danish households: Generation and composition. *Waste Management*, 52, 256-268. https://doi.org/10.1016/j.wasman.2016.03.032

Edwards, J., Othman, M., Burn, S., & Crossin, E. (2016). Energy and time modelling of kerbside waste collection: Changes incurred when adding source separated food waste. *Waste Management*, 56, 454-465. https://doi.org/10.1016/j.wasman.2016.06.033

Einhorn, H.J., Hogarth, R.M., & Klempner, E. (1977). Quality of group judgment. *Psychological Bulletin,* 84(1), 158-172. https://doi.org/10.1037/0033-2909.84.1.158

Eriksson, M., Persson-Osowski, C., Malefors, C., Björkman, J., & Eriksson, E. (2017). Quantification of food waste in public catering services – A case study from a Swedish municipality. *Waste Management*, 61, 415-422. https://doi.org/10.1016/j.wasman.2017.01.035

Eriksson, M., Strid, I., & Hansson, P.A. (2016). Food waste reduction in supermarkets – Net costs and benefits of reduced storage temperature. *Resources, Conservation and Recycling*, 107, 73-81. https://doi.org/10.1016/j.resconrec.2015.11.022

European Commission. (2012). *Commission staff working document-impact assessment-accompanying the document-council decision-on the Association of the overseas countries and territories with the European Union* ("Overseas Association Decision"). https://www.eerstekamer.Nl/Eu/europeesvoorstel/Swd_2012_194_Impact_Assessment_On/Document/F=/Vj20ix6jsiky.pdf

FAO (2015). The state of food insecurity in the world 2015: Meeting the 2015 international hunger targets: taking stock of uneven progress. Rome: FAO. Available at: https://academic.oup.com/advances/article/6/5/623/4558110

Gelbert M. (1996). *The Concept of Environmental Education and the "Wall Chart". Environmental Education handbook.* Malang: PPPGT/VEDC.

Geislar, S. (2017). The new norms of food waste at the curb: Evidence-based policy tools to address benefits and barriers. *Waste Management*, 68, 571-580. https://doi.org/10.1016/j.wasman.2017.07.010

Goh, E., & Jie, F. (2019). To waste or not to waste: Exploring motivational factors of Generation Z hospitality employees towards food wastage in the hospitality industry. *International Journal of Hospitality Management*, 80(January), 126-135. https://doi.org/10.1016/j.ijhm.2019.02.005

Hebrok, M., & Boks, C. (2017). Household food waste: Drivers and potential intervention points for design – An extensive review. *Journal of Cleaner Production*, 151, 380-392. https://doi.org/10.1016/j.jclepro.2017.03.069

Ilakovac, B., Iličković, M., & Voća, N. (2018). Food waste drivers in Croatian households. *Journal of Central European Agriculture*, 19(3), 678-709. https://doi.org/10.5513/JCEA01/19.3.1994

Indriartiningtias, R., Subagyo, & Hartono, B. (2018). Creativity in organization: A literature review. *IEEE International Conference on Industrial Engineering and Engineering Management* (1787-1791). https://doi.org/10.1109/IEEM.2017.8290199

Irani, Z., Sharif, A.M., Lee, H., Aktas, E., Topaloğlu, Z., Wout, T. et al. (2018). Managing food security through food waste and loss: Small data to big data. *Computers and Operations Research*, 98, 367-383. https://doi.org/10.1016/j.cor.2017.10.007

Janssen, A.M., Nijenhuis-de-Vries, M.A., Boer, E.P.J., & Kremer, S. (2017). Fresh, frozen, or ambient food equivalents and their impact on food waste generation in Dutch households. *Waste Management*, 67, 298-307. https://doi.org/10.1016/j.wasman.2017.05.010

Kanungo, S., & Bhatnagar, V.V. (2002) Beyond generic models for information system quality: The use of Interpretive Structural Modeling (ISM). *Systems Research and Behavioral Science,* 19, 531-549. https://doi.org/10.1002/sres.476

Kasavan, S., Mohamed, A.F., & Abdul-Halim, S. (2019). Drivers of food waste generation: Case study of island-based hotels in Langkawi, Malaysia. *Waste Management*, 91, 72-79. https://doi.org/10.1016/j.wasman.2019.04.055

Khalid, S., Naseer, A., Shahid, M., Mustafa-Shah, G., Irfan-Ullah, M., Waqar, A. et al. (2019). Assessment of nutritional loss with food waste and factors governing this waste at household level in Pakistan. *Journal of Cleaner Production*, 206, 1015-1024. https://doi.org/10.1016/j.jclepro.2018.09.138

Ko, W.H., & Lu, M.Y. (2020). Evaluation of the professional competence of kitchen staff to avoid food waste using the modified delphi method. *Sustainability (Switzerland)*, 12(19), 1-11. https://doi.org/10.3390/su12198078

Laureri, F., Minciardi, R., & Robba, M. (2016). An algorithm for the optimal collection of wet waste. *Waste Management*, 48, 56-63. https://doi.org/10.1016/j.wasman.2015.09.020

Leverenz, D., Hafner, G., Moussawel, S., Kranert, M., Goossens, Y., & Schmidt, T. (2021). Reducing food waste in hotel kitchens based on self-reported data. *Industrial Marketing Management*, 93(September 2019), 617-627. https://doi.org/10.1016/j.indmarman.2020.08.008

Liegeard, J., & Manning, L. (2020). Use of intelligent applications to reduce household food waste. *Critical Reviews in Food Science and Nutrition*, 60(6), 1048-1061. https://doi.org/10.1080/10408398.2018.1556580

Liu, C., Hotta, Y., Santo, A., Hengesbaugh, M., Watabe, A., Totoki, Y. et al. (2016). Food waste in Japan: Trends, current practices and key challenges. *Journal of Cleaner Production*, 133, 557-564. https://doi.org/10.1016/j.jclepro.2016.06.026

Lozano-Miralles, J.A., Hermoso-Orzáez, M.J., Martínez-García, C., & Rojas-Sola, J.I. (2018). Comparative study on the environmental impact of traditional clay bricks mixed with organic waste using life cycle analysis. *Sustainability (Switzerland)*, 10(8). https://doi.org/10.3390/su10082917

Maharrani, A., & Syaifudin, N. (2020). *Ada Asa Pengelolaan Sampah di Surabaya*. Lokadata.Id. Available at: https://lokadata.id/artikel/ada-asa-kelola-sampah-disurabaya

Malone, D. (1975). An Introduction to the Application of Interpretive Structural Modelling. *Proceedings of IEEE*, 63, 397-404.

Marzouk, M., & Azab, S. (2014). Environmental and economic impact assessment of construction and demolition waste disposal using system dynamics. *Resources, Conservation and Recycling*, 82, 41-49. https://doi.org/10.1016/j.resconrec.2013.10.015

Mena, C., Terry, L.A., Williams, A., & Ellram, L. (2014). Causes of waste across multi-tier supply networks: Cases in the UK food sector. *International Journal of Production Economics*, 152, 144-158. https://doi.org/10.1016/j.ijpe.2014.03.012

Morana, A., Squillaci, G., Paixao, S. M., Alves, L., La Cara, F., & Moura, P. (2017). Development of an energy biorefinery model for chestnut (*Castanea sativa* Mill.) shells. *Energies*, 10(10), 1504. https://doi.org/10.3390/en10101504

Mulyana, I.J., Gunawan, I., & Tamara, V. (2019). Studi Eksploratif Manajemen Sampah Makanan pada Jaringan Toko Produk Pangan di Indonesia. *Industria: Jurnal Teknologi dan Manajemen Agroindustri*, 8(2), 95-106. https://doi.org/10.21776/ub.industria.2019.008.02.3

Nguyen-Trong, K., Nguyen-Thi-Ngoc, A., Nguyen-Ngoc, D., & Dinh-Thi-Hai, V. (2017). Optimization of municipal solid waste transportation by integrating GIS analysis, equation-based, and agent-based model. *Waste Management*, 59, 14-22. https://doi.org/10.1016/j.wasman.2016.10.048

Ogunranti, G. A.; Oluleye, A. E. (2016). Minimizing waste (Off-Cuts) using cutting stock model: The case of one dimensional cutting stock problem in wood working industry. *Journal of Industrial Engineering and Management*, 9(3), 834-859. https://doi.org/10.3926/jiem.1653

Okumus, B. (2020). How do hotels manage food waste? evidence from hotels in Orlando, Florida. *Journal of Hospitality Marketing and Management*, 29(3), 291-309. https://doi.org/10.1080/19368623.2019.1618775

Oreopoulou, V, & Russ, W. (2007). Utilization of by-products and treatment of waste in the food industry. *Conference proceedings* (3. 209-232). Springer. Available at: https://download.e-bookshelf.de/download/0000/0013/27/L-G-0000001327-0002335190.pdf

Ozgen-Genc, T., & Ekici, A. (2022). A new lens to the understanding and reduction of household food waste: A fuzzy cognitive map approach. *Sustainable Production and Consumption*, 33, 389-411. https://doi.org/10.1016/j.spc.2022.07.010

Papargyropoulou, E., Lozano, R., Steinberger, J.K., Wright, N., & Ujang, Z. (2014). The food waste hierarchy as a framework for the management of food surplus and food waste. *Journal of Cleaner Production*, 76, 106-115. https://doi.org/10.1016/j.jclepro.2014.04.020

Papargyropoulou, E., Wright, N., Lozano, R., Steinberger, J., Padfield, R., & Ujang, Z. (2016). Conceptual framework for the study of food waste generation and prevention in the hospitality sector. *Waste Management*, 49, 326-336. https://doi.org/10.1016/j.wasman.2016.01.017

Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: quantification and potential for change to 2050. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365(1554), 3065-3081. https://doi.org/10.1098/rstb.2010.0126

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

Pemkot-Surabaya (2023). *Peraturan Walikota Surabaya Nomor 4 Tahun 2023. Tentang. Rencana Aksi Daerah Pangan dan Gizi Kota Surabaya tahun 2023-2024.* Available at: https://jdih.surabaya.go.id/uploads/peraturan/2023perwali3578004.pdf

Poduval, P.S., Pramod, V.R., & Jagathy-Raj, V.P. (2015). Interpretive structural modeling (ISM) and its application in analyzing factors inhibiting implementation of total productive maintenance (TPM). *International Journal of Quality and Reliability Management,* 32(3), 308-331. https://doi.org/10.1108/IJQRM-06-2013-0090

Ponis, S.T., Papanikolaou, P.A., Katimertzoglou, P., Ntalla, A.C., & Xenos, K.I. (2017). Household food waste in Greece: A questionnaire survey. *Journal of Cleaner Production*, 149, 1268-1277. https://doi.org/10.1016/j.jclepro.2017.02.165

Principato, L., Di-Leo, A., Mattia, G., & Pratesi, C.A. (2021). The next step in sustainable dining: the restaurant food waste map for the management of food waste. *Italian Journal of Marketing*, 2021(3), 189-207. https://doi.org/10.1007/s43039-021-00032-x

Reitemeier, M., Aheeyar, M., & Drechsel, P. (2021). Perceptions of food waste reduction in sri lanka's commercial capital, Colombo. *Sustainability (Switzerland)*, 13(2), 1-16. https://doi.org/10.3390/su13020838

Rizanty, M. A. (2022). *Sampah di Jakarta Kebanyakan Berupa Sisa Makanan*. Retrieved July 11 2022, from https://databoks.katadata.co.id/datapublish/2022/05/30/sampah-di-jakarta-kebanyakan-berupa-sisa-makanan#:~:text=Menurut%20data%20Kementerian%20Lingkungan%20Hidup,proporsi%20mencapai%2027%2C8%25

Roodhuyzen, D.M.A., Luning, P.A., Fogliano, V., & Steenbekkers, L.P.A. (2017). Putting together the puzzle of consumer food waste: Towards an integral perspective. *Trends in Food Science and Technology*, 68, 37-50. https://doi.org/10.1016/j.tifs.2017.07.009

Ryan-Fogarty, Y., Becker, G., Moles, R., & O'Regan, B. (2017). Backcasting to identify food waste prevention and mitigation opportunities for infant feeding in maternity services. *Waste Management*, 61, 405-414. https://doi.org/10.1016/j.wasman.2016.12.029

Salomone, R., Saija, G., Mondello, G., Giannetto, A., Fasulo, S., & Savastano, D. (2016). Environmental impact of food waste bioconversion by insects: Application of Life Cycle Assessment to process using Hermetia illucens. *Journal of Cleaner Production*, 1-16. https://doi.org/10.1016/j.jclepro.2016.06.154

Sastrawijaya, A.T. (2000). *Environmental Pollution.* Ministry of Education and Culture. Rineka Cipta. Available at: http://perpus-lpmpkaltim.kemdikbud.go.id//index.php?p=show_detail&id=1792

Samsuddin, Z., Mastura-Zainal, N.A., Nurhanifah-Sulong, S., & Faizal-Abu-Bakar, A.M. (2022). Handling Food Waste in The Hotel Industry. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 7(11), e001926. https://doi.org/10.47405/mjssh.v7i11.1926

Schanes, K., Dobernig, K., & Gözet, B. (2018). Food waste matters – A systematic review of household food waste practices and their policy implications. *Journal of Cleaner Production,* 182, 978-991. https://doi.org/10.1016/j.jclepro.2018.02.030

Shearer, L., Gatersleben, B., Morse, S., Smyth, M., & Hunt, S. (2017). A problem unstuck? Evaluating the effectiveness of sticker prompts for encouraging household food waste recycling behaviour. *Waste Management*, 60, 164-172. https://doi.org/10.1016/j.wasman.2016.09.036

Simpson, J.J., & Simpson, M. (2014). *Structural modeling*. Available at: https://www.researchgate.net/profile/Joseph-Simpson-10/publication/266138960_Structural_Modeling/links/542615d90cf2e4ce9406faae/Structural-Modeling.pdf (Accessed: April 2022).

Stangherlin, I.C., & de Barcellos, M.D. (2018). Drivers and barriers to food waste reduction. *British Food Journal*, 120(10), 2364-2387. https://doi.org/10.1108/BFJ-12-2017-0726

Swaminathan, M.S. (2015). Food Losses and Food Waste. *Combating Hunger and Achieving Food Security*, 37-46. https://doi.org/10.1017/cbo9781316389485.009

Tanguy, A., Villot, J., Glaus, M., Laforest, V., & Hausler, R. (2017). Service area size assessment for evaluating the spatial scale of solid waste recovery chains: A territorial perspective. *Waste Management*, 64. https://doi.org/10.1016/j.wasman.2017.03.027

Tatàno, F., Caramiello, C., Paolini, T., & Tripolone, L. (2017). Generation and collection of restaurant waste: Characterization and evaluation at a case study in Italy. *Waste Management*, 61, 423-442. https://doi.org/10.1016/j.wasman.2017.01.020

Thamagasorn, M., & Pharino, C. (2019). An analysis of food waste from a flight catering business for sustainable food waste management: A case study of halal food production process. *Journal of Cleaner Production*, 228(2019), 845-855. https://doi.org/10.1016/j.jclepro.2019.04.312

Thyberg, K.L., & Tonjes, D.J. (2016). Drivers of food waste and their implications for sustainable policy development. *Resources, Conservation and Recycling*, 106, 110-123. https://doi.org/10.1016/j.resconrec.2015.11.016

Tomaszewska, M., Bilska, B., Tul-Krzyszczuk, A., & Kołożyn-Krajewska, D. (2021). Estimation of the scale of food waste in hotel food services – A case study. *Sustainability (Switzerland)*, 13(1), 1-16. https://doi.org/10.3390/su13010421

Tromp, S.O., Haijema, R., Rijgersberg, H., & van der Vorst, J.G.A.J. (2016). A systematic approach to preventing chilled-food waste at the retail outlet. *International Journal of Production Economics*, 182, 508-518. https://doi.org/10.1016/j.ijpe.2016.10.003

United Nations Environment Programme. (2021). *Food Waste Index Report 2021*. ISBN: 978-92-807-3868-1.

van der Horst, H., Pascucci, S., & Bol, W. (2014). The "dark side" of food banks? Exploring emotional responses of food bank receivers in the Netherlands. *British Food Journal*, 116(9), 1506-1520. https://doi.org/10.1108/BFJ-02-2014-0081

van der Vorst, J.G.A.J., Beulens, A.J.M., Wit, W., & van Beek, P. (1998). Supply chain management in food chains: Improving performance by reducing uncertainty. *International Transactions in Operational Research*, 5(6), 487-499. https://doi.org/10.1111/j.1475-3995.1998.tb00131.x

Wang, L., Liu, G., Liu, X., Liu, Y., Gao, J., Zhou, B. et al. (2017). The weight of unfinished plate: A survey based characterization of restaurant food waste in Chinese cities. *Waste Management*, 66, 3-12. https://doi.org/10.1016/j.wasman.2017.04.007

Westendorf, M.L. (2000). *Food Waste to Animal Feed* (113-144). Wiley Online Library. https://doi.org/10.1002/9780470290217

Xu, Z., Elomri, A., Pokharel, S., Zhang, Q., Ming, X.G., & Liu, W. (2017). Global reverse supply chain design for solid waste recycling under uncertainties and carbon emission constraint. *Waste Management*, 64, 358-370. https://doi.org/10.1016/j.wasman.2017.02.024

Zhang, Y., Huang, G.H. & He, L. (2014). A multi-echelon supply chain model for municipal solid waste management system. *Waste Management*, 34(2), 553-561. https://doi.org/10.1016/j.wasman.2013.10.002

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