Food Waste in Supply Chains: A Literature Review

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Abstract
Food waste has been a growing issue in supply chain management (SCM) research. The number of articles in international journal and conferences papers consistently rises in the last decade. This paper examines the publication trend of food waste research, particularly in the supply chain context. 108 articles in Scopus database published in 2006 to 2018 are reviewed. The papers are classified based on the type of food waste, keywords, method used, and future research issues. This study provides an basis for SCM researchers in understanding the potential development of the current research for food waste in supply chain.
Keywords - Food waste, supply chain, literature review

1. INTRODUCTION

Food waste is a removed food and no longer feasible to be consumed by humans because of the damage or other causes. While food wastage includes both, food lost and food waste (Parfitt et al. 2010). In general, wasted food is not used can be called food loss or food wastage. According to the FAO, food waste is food that is available and consumed but the food has decreased the weight and nutritional value (Najoan et al. 2016).

One of the food waste with the high risk is agricultural industry food. Agricultural industry food is easily decayed and damaged, for instance fruit and vegetable in one supply chain (harvesting, handling, distributing, and marketing) (Salemdeeb et al. 2017). Managing agriculture and food logistics in Indonesia are still traditional in controlling method, harvesting, disrupting disaster (Syahrir et al. 2015) and decaying as an impact of distribution process (Vanany et al. 2010 and Vanany et al. 2016) become important causes of high food waste in Indonesia.

Food waste has become a problem in various countries of the world, one of which France and Germany became a serious European country facing food waste. France requires supermarkets to hand over food to a charity. Food waste has reached the European Parliament and the issuance of the rules of utilization of food waste in the supermarket. Then, supermarket must sell the defective vegetables with the lower price than the ordinary vegetables. (Parfitt et.all 2010, Lozano,2014)

In its implementation, the industry needs to consider food waste of vegetables and fruits, starting from upstream suppliers, factories, distributions, downstream that is distributors and consumers (Parfitt et al. 2010). Research in the UK in 2011 found the amount of food waste for vegetables and fruits about 1.3 billion tons per year, that number represents one-third of the food produced for human consumption. The country is progressing 1,500 calories per day per person wasted in vain. In developing countries too, an estimated 400-500 calories per day per person is wasted, of which 40% of losses occur in retail and consumers, another 40% of losses occur post-harvest and processing. so the total food waste consumed in industrialized countries reached 222 million tons.

Recent research conducted by the World Food Agency FAO along with research institutes for organic farming and London School of Economics shows the increasing threat of food waste vegetables and fruits are wasted on food security and sustainability. Now a third or 1.7 billion tons per year of total world food production is lost as waste. The value of economic losses or direct losses amounts to one trillion US dollars (Salomone 2016). Not only that, the hidden costs or losses by food waste of vegetables and fruits also cover the negative impact on the environment (global environmental costs) which is estimated to reach the value of US $ 700 billion and social costs (social costs) US $ 900 billion. So the total loss due to global food waste reaches the US $ 2.6 trillion per year or 4% of the world's gross product.

This paper describes the literature review related to the food waste supply chain. this study is limited to food waste in supply chain issues. This paper aims to contribute to further research focusing on optimizing the model of

collecting food waste for further use as a reusable, recyclable, energy-consuming, or totally unusable (discarded) material.

2. METHODOLOGY

Google Scholar journals and Scopus database were selected as the data source in this review because it is one of the popular, indexed and biggest research articles for scientific bibliometric analysis (Indriartiningtias et al. 2017). First step, Google Scholar journals and Scopus database were chosen because of a more comprehensive academic source with more than 5,000 publishers, indexed and organized to support research needs. second step, the keywords used to search titles, abstracts, and author keywords are "food_waste" or "waste_food " or "foodwaste" or "wastefood" or "waste" or "waste and agriculture" or "waste_agriculture" or "waste and supply chain" from 2006 to 2018 (Chen et al. 2016). All articles related to the keywords used are 562013 and of the most frequently used article types, there are 1869 articles that have been filtered based on the document type is article, subject area (Environmental science, Agricultural and biological sciences, engineering), source title (waste management, environmental science and technology, environmental science and environmental journals), source type (journals), keywords (food waste, waste management, food, agriculture, waste management, supply chain).

The next step is determining the criteria of articles that discuss food waste with by using Microsoft Excel 2013 version, articles are sorted back to suitability based on disciplines namely Industrial Engineering and Food-focused. From the results of excel obtained 108 articles.

3. RESULTS

This section provides an overview of paper analysis using tables to simplify the explanation.

3.1. Annual distribution of published articles

Food waste research articles are dominated by big countries like USA, UK, Japan, Canada, and others. Fig. 1 shows that the number of food waste publications decreased in 2002 and 2009, in 2006, 2007, 2008 and 2010 the number of food waste publications remained in the previous year, another year the number of food waste publications increased slowly and sharp increases were seen in 2017.
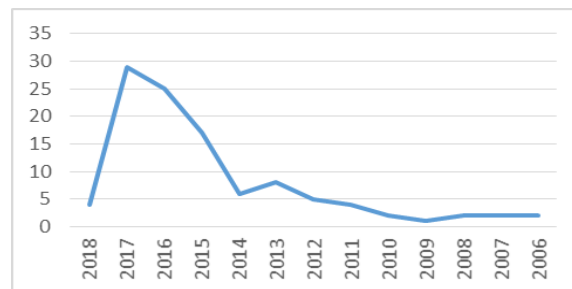

Fig.1 The number food waste research started from 2006 to 2018

In 2014, the number of food waste articles increased from 6 articles to 17 articles in 2015, the number continues to rise in 2016, which is 25 articles and 29 articles in 2017. This shows that research on food waste is very interesting and likely to be one effort to minimize food waste.

3.2. Publication Patterns: Source Titles

108 articles by name of the journal are divided into environmental and technological sciences, resource conservation and recycling, Proceeding environmental, engineering and management, sustainability (Switzerland) and waste management. waste management of the highest amount of 93 articles and Environmental Science and Technology there are 12 articles. Fig. 2 shows a chart of 108 articles based on the name of the journal published in the Scopus.
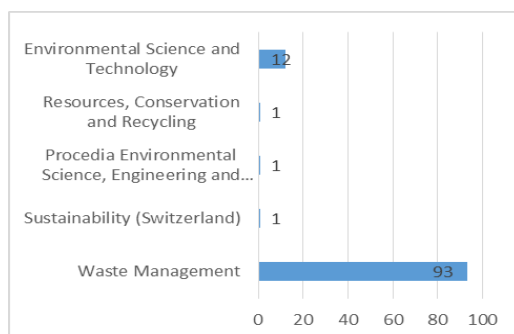
Fig.2: The growth trends of the journal

3.3. Type of waste

The most frequently discussed types of waste in 108 food waste research articles are solid type, liquid type, organic type, hazardous type, recyclable type.

TABLE 1 RESEARCH ARTICLES BASED ON TYPE OF WASTE

Type of Food Waste	Author
Hazardous	Hartikainen *et al.* (2018), Mu *et al.* (2017), Wang *et al.* (2017), Painter, Thondhlana and Kua (2016), Woon *et al.* (2016), Woon and Lo (2016), Bernstad and la Cour Jansen (2012), Bing *et al.* (2016), Chalak *et al.* (2016)
Organic	Martinho *et al.* (2018), Muriana (2017), Janssen *et al.* (2017), Shearer *et al.* (2017), Edjabou *et al.* (2017), Girotto, Alibardi and Cossu (2015), Beretta *et al.* (2013), Bernstad and La Cour Jansen (2012), Nahman *et al.* (2012), Gentil, Gallo and Christensen (2011), Giugliano *et al.* (2011), Strotmann (2017), Delley and Brunner (2017), Confalonieri (2016), Slack *et al.* (2007), Walsh (2002), Hartikainen *et al.* (2018), Zhang and Jiang (2017), Salemdeeb *et al.* (2017), Faleschini *et al.* (2016), Muriana (2015), Hupponen, Grönman and Horttanaine (2015), Kinobe *et al.* (2015), Zhang, Huang and He (2014), Giuseppe, Mario and Cinzia (2014), Nahman *et al.* (2013)
Liquid	Geislar (2017), Evangelisti *et al.* (2017), Ju, Osako and Harashina (2017), Willersinn *et al.* (2017), Chalak *et al.* (2016), Richter and Bokelmann (2016), De Lange and Nahman (2015), Edjabou *et al.* (2015), Betz *et al.* (2015), Lebersorger and Schneider (2014), Salhofer *et al.* (2008), Edjabou *et al.* (2015), Dias-Ferreira, Santos and Oliveira (2015), Xue (2017), Shafiee-Jood and Cai (2016), Xu *et al.* (2017), Ju, Osako and Harashin (2017), Shafiee-Jood (2016), Richter and Bokelmann (2016), Betz *et al.* (2015), Liu *et al.* (2013), Beretta *et al.* (2013)
Recyclable	Bees and Williams (2017), Ryan-Fogarty *et al.* (2017), Heikkilä *et al.* (2016), Stoknes *et al.* (2016), Edwards *et al.* (2016), Papargyropoulou *et al.* (2014), Parizeau, von Massow and Martin (2015), Silvennoinen *et al.* (2015), Karim Ghani *et al.*, 2013), Lebersorger and Schneider (2014), Levis *et al.* (2010), Ağdağ (2009), Zhuang *et al.* (2008), Laureri, Minciardi and Robba (2016), Martinez-Sanchez *et al.* (2016), Hamilton *et al.* (2015), Muriana (2017), Xu *et al.* (2017), Tanguy *et al.* (2017), Eriksson *et al.* (2017), Santibañez-Aguilar *et al.* (2013), Nahman *et al.* (2012)
Solid	Abdelradi (2018), Maalouf and El-Fadel (2017), Edjabou *et al.* (2017), Tanguy *et al.* (2017), Eriksson *et al.* (2017), Tatàno *et al.* (2017), Salemdeeb *et al.* (2017), Bell *et al.* (2016), Khan, Kumar and Samadder (2016), Laureri, Minciardi and Robba (2016), Dias-Ferreira, Santos and Oliveira (2015), Rispo, Williams and Shaw (2015), Li *et al.* (2014), Bernstad (2014), Lebersorger and Schneider (2014), Giuseppe, Mario and Cinzia (2014), Nahman and de Lange (2013), Liang and Zhang (2012), Zhao *et al.* (2011), Hung, Ma and Yang (2007), Hui *et al.* (2006), El-Mobaidh, Razek Taha and Lassheen (2006), Grugnaletti *et al.* (2016), Allesch and Brunner (2017), Powell, Pons and Chertow (2016), Kaufman, Krishnan and Themelis (2010), Girotto, Alibardi and Cossu (2015), Li *et al.* (2015), Willersinn *et al.* (2015)

Liquid type is a waste comes from wastewater, rainwater or solid waste that is liquefied for disposal. Solid type is solid waste from both waste of production process and garbage from household and elsewhere. Hazardous type is a waste that has the potential to threaten public health and the environment because it is flammable, reactive, corrosive and toxic. Organic type: is garbage derived from plants or animals, such as food waste, rotten fruits and vegetable or fruit skins. Animal waste also includes organic waste. Recyclable type: is waste that can be recycled into a new product that is useful to reduce the use of raw materials (Eschool 2017).

Table 1 shows types of food waste research in the 108 selected articles. The most commonly feared types of food waste are the solid type (29 articles), hazardous type (9 articles), recyclable type (22 articles), organic type (26 articles), and liquid type (22 articles)

3.4. Author keywords

Author keyword analysis, Keywords used in 108 research articles indicate that the author's keyword is used more than three times.
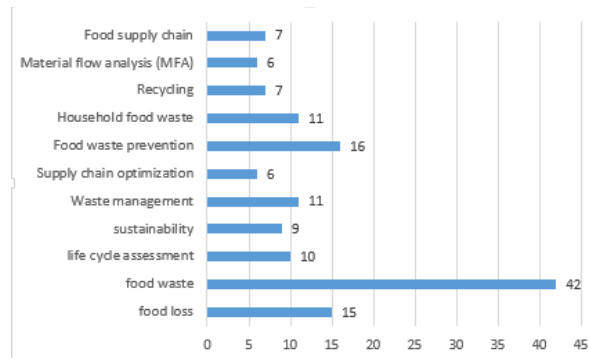
Fig 3. The growth trends of author keywords

Fig. 3 shows ten of the most commonly used author keywords along with their numbers. Through analysis to attract research trends, the ten most frequent keyword authors except food waste (38%) are food waste prevention 14%, food loss 13%, waste manajemen and house hold food waste respectively 10%, life cycle assessment 9%, sustainability 8%, food supply chain 6%, Supply chain optimization and material flow analysis respectively 5%.

3.5. Method research

From the analysis of 108 articles selected, the methods used include : (1). survey is a research conducted in a population with the aim of finding relationships between variables or distribution, (2). experiment is research that aims to find the influence between variables, (3). explorative is research that aims to find a new science, (4). modeling is theory testing with mathematic, (5). confirmatory is Theory testing with question and answer, (6). Case study is a research method in which the question "how" and "why" is proposed in a study, (7). Descriptive is research that aims to describe things that happen today, (8). Policy research is aimed at researching social problems, (9). Action research is a study that aims to find the most effective method, and (10). Evaluation research (is a study that aims to test the truth of existing science). In the study of this research method there is also a journal review (Husey 1997)].
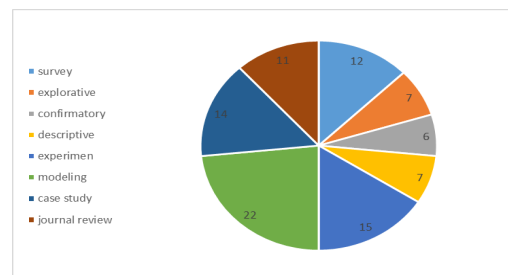

Fig. 4 Number of method research

In Fig.4 the most commonly used research method is modeling that there are 22 journals. Another research model is the most widely used is the experiment, there are 15 journals

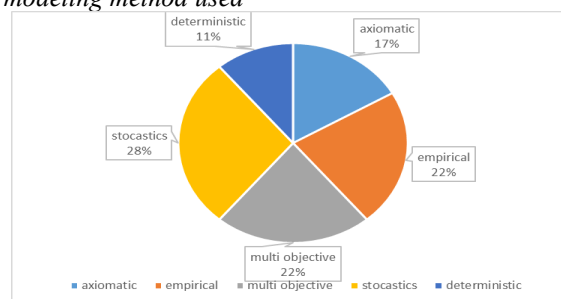*a Article analysis based on the modeling method used*

Fig. 5 Number of modeling method research used

One of the journals reviewing modeling (Geislar 2017, Evangelisti et al. 2017, Willersinn et al. 2017). Tanguy performs waste recovery management by creating territorial features (waste and production sites). The research discussed in this article uses a systemic approach to estimate the size of the service area chain based on a balance between cost and profitability. The model assigns an integrated part of the municipal solid waste management system, but the broad size of the facility services becomes a sensitive issue as the calculations depend on processing technology (Tanguy et al. 2017).

b. Article analysis based on the experiment method used
The other most widely used experimental model is the experiment, there are 15 journals, one of which is research (Martinho et al. 2018). In his research, Abdelradi conducted an analysis of consumer behavior regarding food waste in Egypt. Models tested using structural equation modeling, factors obtained as findings suggest developing local government policies in Egypt and launching new campaigns for food waste reduction (Abdelradi 2018).

4. DISCUSSION

Use This paper analyzes the development of food waste research in the supply chain during 2006 to 2018. Increased investment in food waste increased significantly since 2015 due to government policies in several countries to develop waste collection program, reducing greenhouse gas (Geislar 2017), resulting in studies that examine government policies in terms of economic, environmental and social impacts (Papargyropoulou et al. 2014) and there are even studies that contribute to waste planning and processing (Bell et al. 2016).

During the study period, Keywords other than food waste (39%), other frequently used keywords were the prevention of food waste (15%), food loos (13%) and waste management (10%). Although based on research [1] that the food waste for vegetables and fruits is about 1.3 billion tons per year, that figure represents one-third of the food produced for human consumption, but during this study period the article found only 2 types of food waste research which are discussed in agriculture (Hartikainen et al. 2018) and composting. Although composting is not a new method of food waste treatment, the characteristics of compostable food waste still present a unique challenge for researchers, because the basic knowledge of composting food waste is insufficient to support maximum process with high efficiency, there are 7 journals (6%) discuss composting (Martinho et al. 2018).

Another thing that becomes an issue is the utilization of food waste is as an alternative energy (Woon et al. 2016, Giugliano et al. 2011). The study of food waste management, especially recycling (Martinho et al. 2018, Bees et al. 2017, Laureri et al. 2016), and the discussion of preventive reduction of food waste also attracted attention (Ryan-Fogarty et al. 2017, Painter et al. 2016). Other author keywords often use supply chain optimization, food waste generation, An-aerobic digestion, Efficiency, Consumer behaviour, and life cycle assessment. In addition, it was found that the two keyword authors of "Sustainability" had very high growth rates, per cent of these words occurred in the last 8 years, which implies this important research direction have aroused special interest recently and may represent to the border in the food waste field. "'Sustainability' is certain shows that sustainable development of food waste management is a food waste-inspired hotspot and has grown to an international level: recognition of food loss and waste announced at the United Nations Conference on Sustainable Development as a component of the Zero (Philips et al. 1990).

Research issues that the researcher wants to raise by keyword are the collection, discussion about a collection of 108 articles. Firstly, separation of household waste separately for anaerobic digestion is one of the methods used in biodegradable in the UK (Bees 2017). Secondly, evaluation implementation of waste food waste at a case study restaurant in the coastal area of Central Italy (Tatano et al. 2017). Thirdly, a sustainable waste collection and recycling framework for renewable biogas fuel production is proposed in Hong Kong (Edwards et al. 2016). Fourth, this work refers to the development of an approach to planning the collection of wet wastes (food and other waste) on a metropolitan scale (Laureri et al. 2016). Some specific modelling features differentiate this specific garbage collection problem from others. The most widely used method in 108 articles is 20% modelling method and 15 articles using experimental model (13%). Other methods that are minimally used are action research and historical research.

5. CONCLUSION

Based on 108 publications from Scopus, this bibliometric study provides an overview of research on food waste and identified several key points in the study during the inquiry period. The following conclusions are drawn from this study: (1) The number of food waste articles has increased over the last 12 years, especially in recent years in 2015 a very significant increase. (2). The category of research in the field of food waste mainly focuses on agriculture, chemical engineering, environmental science, energy, and recycle. All outputs have been concentrated in one journal, the waste management journal. (3). Systematically analyzing the author's keyword distribution, it can be concluded that research on the prevention of food and household or urban food waste and waste is more attention and has attracted widespread attention over the past decade. The keyword authors of lifecycle assessments and sustainability have attracted special interest recently and may represent a limit in the Food waste field. It also implies that energy, maintenance and value enhancement, and management innovation are the focal points of decision making and waste management policies for the future. (4). The most commonly used method is modelling, while the simulation has not done the research.

So, from 108 articles in 7 journals that discuss food waste collection, very big chance of researcher to do food waste research along supply chain by making the model collection.

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