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Food Waste Reduction Strategy in the Food Service Sector in Jakarta with Causal Loop Analysis

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Abstract

The need for food continues to increase along with the increase in world population. However, problems in environmental, social and economic aspects arise because some of the food will end up being wasted, in fact, this food waste is produced at every stage in the food supply chain. This problem needs to be of concern to both the government as a regulator and business actors as operators and the public as consumers. Based on research conducted by the Ministry of National Development Planning, the proportion of food waste is mostly generated at the consumption stage. The consumption stage is divided by two actors, food service and households. This paper focuses on discussing the generation of food waste in food services in Jakarta using a causal loop analysis. This study aims to propose a strategy for managing food waste in the food service sector. Causal loop analysis provides an understanding of the flow of food waste generation and the relationship between variables that affect food waste generation. The causal loop diagram provides an overview of the generation of food waste generated from three sources: food suppliers, food services and food banks. Three scenarios are implemented to reduce the level of food waste generation.

Keywords: Causal loop analysis, food service, food waste, waste generation

Introduction

Environmental damage and climate change have become issues that not only get the attention of scientists, but are also highlighted by governments and the general public around the world. Industrial activities that are more intense have an impact on increasing GHG emissions, such as carbon dioxide and methane, which is one of the causes of global

climate change. Apart from industrial activities, another emission source that increases the concentration of greenhouse gases in the atmosphere comes from the process of disposing of solid waste [1]. There are two main things that support the growth of this waste volume. First, the world's population has increased significantly, mainly due to a decrease in the death rate as a result of advances in the world of health. Second, there is an increase in per capita income which results in an increase in demand for goods and services, which results in an increase in the volume of waste. One of the targets of the Paris Agreement is to limit global temperature rise to 1.5 degrees Celsius. Food waste contributes 8% of greenhouse gas emissions (4.4 gigatons of CO2 per year). Reducing emissions from fossil fuels will not have a significant effect on this target if there are no improvements in handling food waste [2].

Every year more than 1.3 billion tons of food is lost (food loss) and wasted (food waste), which is one-third of all food produced worldwide [3]. Food loss is a decrease in the quality and quantity of food from the behavior of food suppliers outside of retail, food service, and consumers. Meanwhile, food waste is a decrease in the quantity or quality of food caused by treatment from retailers, food service providers, or consumers themselves [3]. Food loss and food waste is generated at each stage in the food supply chain, starting from agriculture (agriculture/ livestock), manufacturing (processing and packaging), retail, food service providers, and households.

In Indonesia, a report from the Ministry of Environment and Forestry in 2018 stated that food waste has a 44% share of the total waste generated. Ministry of National Development Planning (PPN/Bappenas), together with a number of other institutions, did a study on food loss and food waste in Indonesia and claimed that Indonesia produced 23-48 million tons of food waste per year in the 2000-2019 period, or the equivalent of 115-184 kilograms per capita per year. The economic losses incurred amount to IDR 213 – 551 trillion/year or equivalent to 4-5 percent of Indonesia's GDP per year. Socially this loss, if converted into food, can meet the food portion of 61-125 million people per year [4]. The generation of food loss and food waste in Indonesia comes from five stages of the food supply chain. Food loss is generated in the first three stages: the production stage, the post-harvest and storage stage, and the processing and packaging stage. Meanwhile food waste comes from the distribution and marketing stage, and the consumption stage. In 2000 food loss accounted for 61% and food waste contributed 39% of all food wasted. Then in 2019 there was a shift in percentage where food loss contributed 45% and food waste contributed 55% of all food wasted. Consumption stage produces 5-19 million tons of food waste per year, and is the stage in the food supply chain that contributes the most to food waste generation. Consumption stage consists of food services and households [4].

The food service sector can be defined as businesses, institutions and companies sell any food outside the household. The food service market continues to grow due to several factors such as an increase in the number of people who are of working age and an increase in the availability of food services that can provide quality food and good service. In addition, rising consumer incomes and an increase variety of foods over the past few years have led to an increase in demand. Heikkilä states that the food waste generated in the food service sector has a significant impact on the environment and the economy, and some of it is food waste that can be avoided [5]. To increase awareness and collaboration in reducing food waste, stakeholders at the macro (authority/government) and micro (food service entrepreneurs) levels should work together. Food waste in this sector is generated in 3 stages: pre-kitchen (in the storage warehouse, before food processing), in the kitchen (during food processing), and post-kitchen, namely waste left on dishes [6]. According to Pirani, factors that affect significantly to the generation of food waste are the style and timing of serving, the type of food served, and the accuracy of predicting the number of customers [7]. Chalak examined food waste generation in the retail and food service sector in 33 developed countries in North America, Europe, Asia and Oceania. The generation of food waste in the food service sector, such as hotels, restaurants, and cafeterias, often occurs because the portion of served food is larger than the portion of food needed by consumers. Cooking procedures and supply-demand planning are also factors related to food waste generation [8]. Food waste issue has become a public problem that puts pressure on the environment and natural resources. This is a complex problem because food waste also has an economic and social impact. Therefore, efforts to reduce food waste are part of a larger food system and are related to the issue of sustainability [3].

Literature Review

The author conducted a literature review of several scientific article references related to this research topic. The purpose of conducting a literature review is to gain in-depth knowledge of the research topic, learn about discussion of related topics in the studies that have been conducted, and find research gaps and research positions. The author reviews several scientific article references related to food waste (food loss and food waste) in general, the condition of food waste in Indonesia, the management of food waste in the food service sector, and the application of the causal loop analysis in food waste management.

The problem of food waste has a major impact on social, economic, and environmental. The most food waste generation occurs at the point of consumption, one of which is in the food service industry sector. Through a literature review, the authors see that there has not been much research on food waste that focuses on the food service industry sector

in Indonesia. Considering that the problem of food waste is a complex problem and is related to various stakeholders that influence one another, the authors consider the causal loop analysis suitable for discussing this topic. Causal loop modeling provides an overall picture of the process of food waste generation and food waste management policies, by assessing the relationship between variables or factors. Therefore, in this paper the authors propose a strategy to reduce food waste in the food service industry sector using the Causal Loop Analysis.

Causal loop analysis is related to system dynamics. System Dynamics is a unique method designed to assist researchers and policy makers in designing and implementing policies for sustainable success [9]. Lee used a system dynamic modeling to evaluate food waste management in Hong Kong in several different scenarios. System Dynamics helps to analyze how different factors and variables influence each other, function and behavior of the system, provide an overview of the feedback structure, and simulate the model using quantitative data. There are several model validation points that need to be done: 1) The causal loop diagram must be related to the main topic, 2) The relationship of equations in the stock flow diagram must be consistent with the relationship described in the causal loop diagram, 3) The behavior of the causal loop and stock flow diagram must adequately represent the system in the real world, 4) The model must run precisely even when experiencing extreme conditions, and 5) Sensitivity analysis [10].

Research Methodology

This research is done in three main stages. Each stage is mutually continuous, where the previous stage affects the work in the next stage.

Early Stage

The first stage is started by determining research topic based on authors' observations. Problems in food waste management became the focus on those observations. Then literature study is done to understand this topic more thoroughly, and the authors must find the research gap and decide the position of this research.

Literature Study

There are four main things related to this research that has been reviewed. They were food supply chain, food waste, food waste management, and system dynamics modelling. These four things are also the main content of this paper, and became the basis of modelling.

Modelling

The authors reviewed some models related to food waste management, then design a causal loop diagram consists of some variables that represent the causal relationship about food waste generation in food

service in Jakarta. The causal loop diagram should be validated by some experts, so that it fully corresponds to the actual conditions. The next steps are gathering needed data and develop a stock and flow diagram to do simulation and apply scenarios, so the author can decide which strategy that can reduce the food waste generation. Model validation will be done by rechecking the accuracy of data and correlation between variables in the model. Then, verification is done by starting a simulation of system dynamics models, and then checking whether the model can run without any bugs or still have to be fixed in terms of variables or formulas.

Discussion

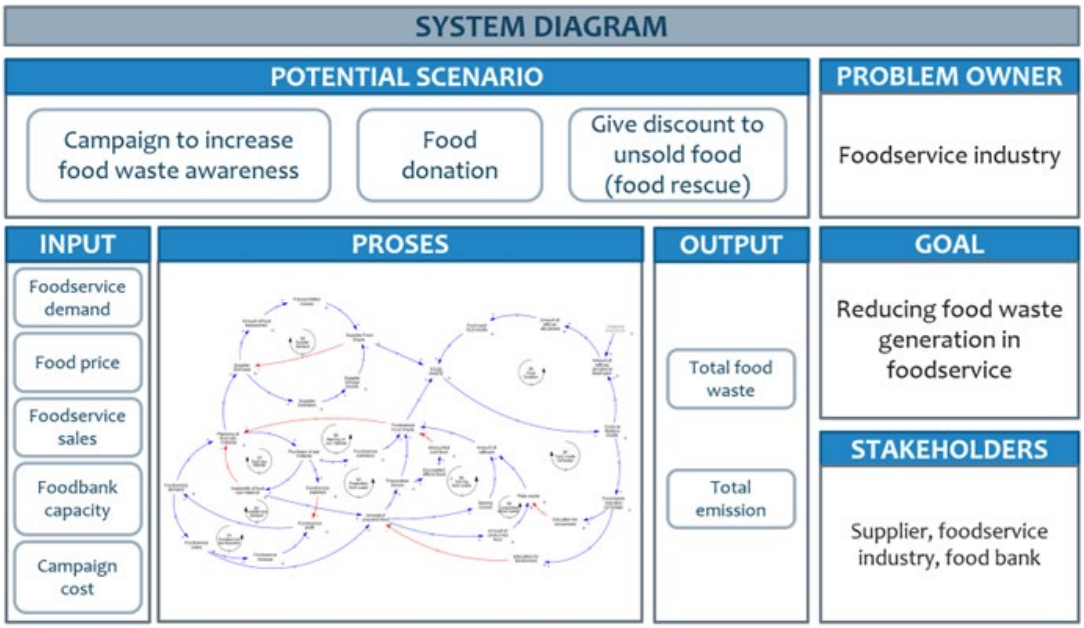
Food waste generation in foodservice in Jakarta is modeled in three stages: system diagram, causal loop diagram, and stock and flow diagram. The data used to build the model is the result of literature studies and interviews with several experts in the food waste management. Some scenarios are applied to find the most appropriate strategy in reducing food waste generation.

System Diagram

System diagrams are essential to assist modelers in understanding the complexity of the systems being researched, because it gives an overall concept of the model. The system diagram contains the following components shown in figure 1: problem owners, the purpose of problem owners to the system under review, stakeholders, strategies that can be applied by problem owners to the system under review, external variables inserted into the system because it affects the system, processes that occur within the system, for dynamic system modeling, are used causal loop diagrams to map the processes that occur within the system, and the output indicator of the system under review determines whether the problem owner's goal is achieved or not [10].

The problem owner in this case is foodservice industry, with the stakeholders are suppliers and food-rescue organization/ institution. A system consists of input, process, and output. As input, the authors need several data such as foodservice demand, food price, foodservice sales, foodbank capacity, and campaign cost. From the designed and simulated model, the author will get total food waste and total emission as output. To achieve the goal, which is reducing food waste generation in foodservice, the authors will apply three potential scenarios to the model: food donation, campaign to increase food waste awareness, and reducing leftover food through selling them with discount price.

Figure 1. System Diagram



Causal Loop Diagram

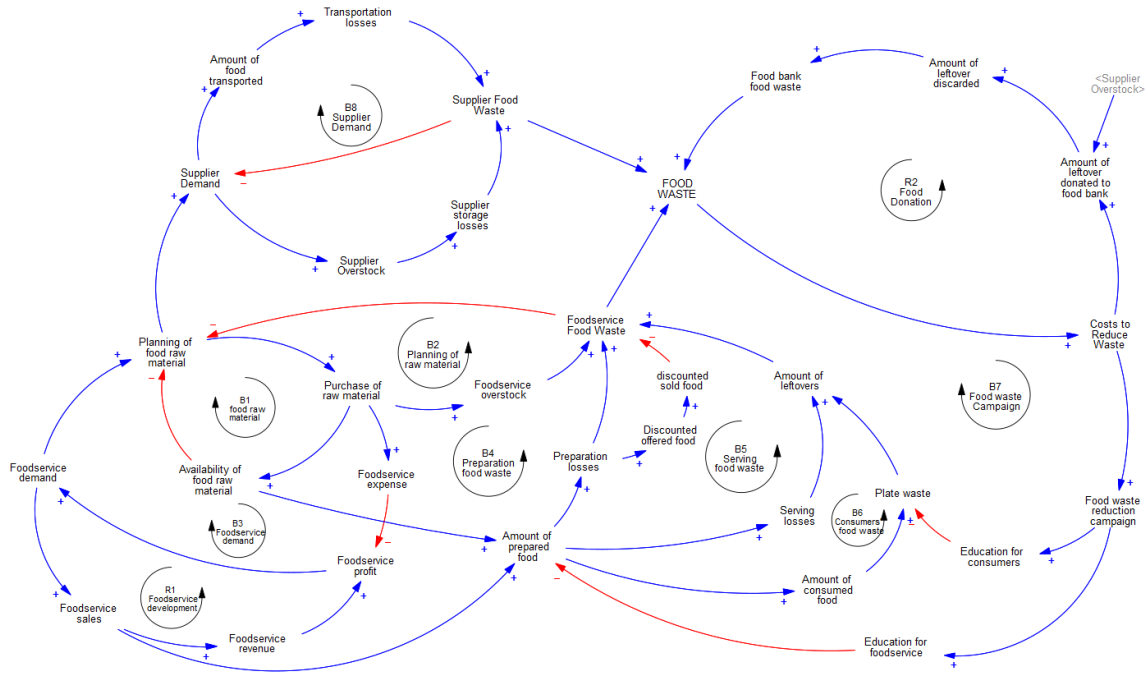
The author combines both reference models of Oktaviasari, Lee, and Buczacki, and has adapted it to the strategy contexts and also the situation of the food waste generation in foodservice in Jakarta, Indonesia [6], [10], [11]. Causal loop diagrams represent the way in which the system works. The relationship of all variables is explained in a causal loop diagram. The variables are connected by arrows which show causal influences between variables. Each arrow is given a polarity, either positive (+) or negative (-) depending on the interaction between variables [11]. The causal loop diagram is made with Vensim software and can be seen in Figure 2.

This paper reviews the food supply chain in three stages: demand fulfillment by food suppliers, processes and consumption done in foodservice, and action to reduce food waste generation. There are three sources of food waste generation, namely food waste from suppliers, food waste from food service, and food waste from excess food bank donations. Suppliers' waste is come from their overstock and transportation losses. Providing the right stock of goods and a safe distribution process will reduce the generation of food waste at suppliers. In foodservice case, food waste is generated in four stages: storage stage, preparation stage, serving stage, and after-eating stage. Storage waste is food raw material foodservice buy from suppliers that unused or expired.

Preparation losses are leftover food ingredients that are removed in the cooking process. Serving losses are cooked food that is not sold until they are no longer edible. Plate waste is leftover food which left on the consumer's plate. Some of suppliers' overstock are donated through food bank. However, not all food is donated. The rest of them have the potential to become food waste.

There are 10 causality loops in the model. Eight of them are balancing loop namely food raw material, planning of raw material, foodservice demand, food waste preparation, serving food waste, consumers' food waste, food waste campaign, and supplier demand. The other two are reinforcing loop namely foodservice development and food donation.

Figure 2. Causal Loop Diagram



Scenarios

After knowing the flow of food waste generation and the relationship between variables that influence each other, the authors designed three scenarios that are expected to reduce the number of food waste generation.

1) Food waste awareness campaign

Campaign and education have a crucial role in minimizing food waste generation. Campaigns are usually in the form of programs and activities that are organized by the government. The expected result of conducting a campaign is enhancing awareness of food waste generation and encouraging public participation in food waste reduction programs [10].

The effectiveness of the campaign needs to be measured to determine how much impact it has on food waste generation. The authors compare the generation of food waste from several levels of the effectiveness of the food waste awareness campaigns.

2) Food donation

The purpose of the food bank is to connect those who have excess food with those who lack food. There is an NGO called the Food Bank of Indonesia which routinely distributes food donations from retailers and suppliers to those in need. Donated food is excess food stock that is not sold but is still suitable for consumption. If not donated, the excess food stock has the potential to become food waste. So, this food donation can be one of the actions to reduce the amount of food waste generated. The authors compare the generation of food waste from several levels of the proportion of food stocks from suppliers that are channeled to food banks.

3) Sell leftover food with discount price

Sometimes a number of foods that have been made or cooked by food services are not completely sold. This food does not have a long shelf life, so it is very likely to expire and be wasted as food waste. Therefore, the author proposes a strategy for food services to selling leftover food at a discounted price a few hours before they close. The authors compare the generation of food waste from several levels of the effectiveness of the food waste awareness campaigns.

Conclusion

Food waste is a problem that still has a lot of potential to find a solution. The generation of food waste cannot be completely eliminated, but the amount can be reduced. This paper proposes three strategic scenarios that are expected to significantly reduce food waste generation. This research will be continued by designing stock and flow diagrams based on causal loop diagrams, and running simulations so that they can be analyzed quantitatively.

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