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Application of Analytic Hierarchy Process in Determining Priorities to Reduce Food Loss and Food Waste in Indonesia

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Abstract— **This study aims to determine the extent of decision-making priorities by using green supply chain management model in overcoming the problem of food waste. This research focused on entities involved in supply chain management and identified their opinions in selecting the level of importance of green supply chain management model. This research applies AHP analysis and using Microsoft Excel which based on Windows 7 to analyse the priorities. Sub-criteria criteria are source, make, deliver, and return. While the sub-criteria are reliability, responsiveness, agility, cost and asset. After doing the research, sub criteria that dominates the formation of food waste is sub criteria deliver, then followed by sub criteria make, source and return. This research found that sub criteria deliver more dominant in donating food waste, followed by source, make and return. Then, in the criteria, the cost criteria are the dominating criteria, then followed by responsiveness, reliability, agility, and asset. This research is useful to acknowledge where the process on supply chain management that causes the occurrence of food waste, so that companies or other organizations can overcome the inefficiency of food in certain process.**

Keywords: AHP; food loss; food waste

1. Introduction

Food waste is wasted food and becomes rubbish. Data from the Food and Agriculture Organization (FAO) under the auspices of the United Nations show that wasted food and food waste have now reached an alarming stage [1]. Indonesia with the fourth largest population in the world turned out to have a great contribution to the world's food waste. Indonesia ranks second in the world's food waste producer as the head of FAO's representative for Indonesia and Timor Leste, Mark Smulders, states that as many as 13 million tons of food in Indonesia are disposed of annually. With a population of around 250 million people, it can be calculated if the needs of Indonesian people's food around 190 million tons per year and 13 million tons is wasted. The amount of food wasted is equal to the number of food needs of 11% of Indonesia's population or about 28 million people and the figure is almost equal to the number of poor Indonesians in 2015.

Indonesia became one of the world's largest food waste contributors due to various factors, one of which is the supply chain. Based on the type of production and distribution process of vegetable and animal products, the food supply chain can be divided into 2 (two) types [2], namely: The food supply chain differs from the supply chain of other products and services. The fundamental difference between food supply chains and other supply chains is the continuous and significant change in the quality of food products throughout the supply chain to the end point, the product is consumed.

Supply chain management can integrate environmental management practices into all supply chain management in order to achieve greener supply chain management and maintain competitive advantage and also to increase business profits and market share objectives. [3] Zhu and Sarkis define Green Supply Chain Management as a management that ranges from green purchasing to integrated supply chains from suppliers, to factories, to customers and reverse logistics, which

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"close loops". Meanwhile, Green Supply Chain Management is an integration of environmental thinking into supply chain management, including product design, source and selection materials, manufacturing process, final delivery of products to consumers and end-of-life product management after its utilization. This study aims to determine the extent of decision-making priorities by using green supply chain management model in overcoming the problem of food waste.

2.   Literature Review
2.1   Supply   Chain   Operation Reference

The SCOR model is the reference of a process-based supply chain operation. This model provides a consistent supply chain management framework, including business   processes,   performance evaluations and improvement practices. This can help all components of the supply chain, including manufacturers, suppliers, retailers, distributors, logistics and customer service providers, to improve supply chain management efficiency by communicating effectively [4].

The scope of the SCOR process is:

1. Plan (planning and management of demand or supply).
2. Source (Supply of inventory, make request)
    a. Schedule delivery, receipt, verify and ship   products   and   authorize procurement payments, as well as direct business regulation, assess procurement performance and store data.
    b. Manage   inventory,   procurement network,   import   /   export requirements,   and   procurement agreements.
3. Make (processes that change the product to the finished stage) include scheduling, processing, testing, packaging, shipping, regulating rules and compliance with production regulations.
4. Deliver: including ordering and invoice from   customer,   transportation management   (delivery),   distribution strategy, receiving and verifying product, logistics, export and import requirements.
5. Return (return of raw materials (procurement) and return of finished goods (from customers) for any reason, including defective products).

The measurement of performance of the supply chain include five categories, such as reliability, reliability, responsiveness, agility, cost and asset management.

2.2   Green   Supply   Chain Management

The concept of Green SCOR is a modification of the SCOR model of streamlining supply chain management and is built by incorporating elements of the environmental management system. The goal is to create an analytical tool that provides an overview of the relationship between supply chain function and environmental aspects in order to create improved management performance between them [5].

In recent years, Green Supply Chain Management (GSCM) has become one of the important strategies to achieve sustainable development for the company [6]. The GSCM concept is a supply chain management that deals with environmental aspects. A "green" based supply chain management is important to implement because the size of supply chain performance usually does not pay attention to the impact on the environment.

2.3   Analytical   Hierarchy   Process (AHP)

In AHP decisions are made by comparing alternatively alternatives to be selected using a questionnaire. AHP handles multiple perspectives (criteria) and actions (sub criteria) with different degrees of interest and translates the overall result into an integrated matrix. The results obtained are to enable managers to find out the perspectives of performance appraisal and to understand the possibility of failure. The steps are as follows: 1. Develop a hierarchy of problems encountered. Problems to be solved, broken down into elements of criteria and alternatives are then organized into hierarchical structures. 2. Assessment criteria and alternatives. Criteria and alternatives are assessed through paired comparisons for various issues. Scales 1 through 9 are the best scales in expressing opinions. 3. Priority Determination. The relative comparison values are then processed to rank alternatives from all alternatives. 4. Logical Consistency. In making decisions, it is important to know how about the consistency, because it is not

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considered to have low consistency. This can be done with steps are:

a. Multiplying each value in the first column with the first priority element, the value in the second column with the second priority element, and so on.
b. Sums up each row.
c. The result of the sum of rows is divided by the relevant priority element.
d. Sum it up with the number of elements available, the result is called λ max.
e. λ max = largest eigenvalue of the matrix.
f. The largest eigen value is obtained by summing the multiplication of the number of columns by eigen vector. The limit of inconsistency is measured by using consistency ratio (CR), i.e. comparison of consistency index (CI) with random consistency value (RI). This value depends on the matrix order n.
g. Calculates the consistency index (CI) with the formula:

$$CI = \frac{\lambda maks - n}{n-1} \qquad (1)$$

Where n is the number of elements.

λ $maks$ = average price calculated before. If CI = 0 then the decision maker is perfectly consistent. While how far such inconsistencies can be accepted. It must be compared to CI with random index that is consistency index of random matched comparation matrix. Price RI can be seen in Table.

h. Calculate the consistency ratio (CR) with the formula:

$$CR = \frac{CI}{IR} \qquad (2)$$

where: CR = Consistency Ratio

CI = Consistency Index

IR = Index Random Consistency

i. Checking the consistency of the hierarchy, if the value is more than 10%, then the judgment data assessment should be corrected. However, if the consistency ratio (CI / IR) is less or equal to 0.1 then the calculation result can be stated correctly [7].

2.4   Food Waste Definition

Food waste is wasted food and becomes rubbish. The definition of waste can be seen from various sides so that various institutions and organizations can use different definitions of waste food or wasted food. Food waste can be seen from its kind, from how waste is formed, and where it comes from [11]. Some foods can be wasted at a certain stage in the processing until finished consumed by humans. Under the Institution of Mechanical Engineers, at least in 2013 half of the total human-produced food is wasted into waste. In poor and developing countries, most food is wasted in production and processing because of inefficient processes. While in developed countries, food is wasted more in terms of consumption and each individual can throw about 100 kg of food per year.

3.   Research Methods

3.1   Objects and Research Tools

This research object research is all entities involved in supply chain management process. In addition, it also uses data from questionnaires that will be filled by all entities that contain supply chain management. The form of the questionnaire used refers to the AHP model by selecting the level of importance on how green the process and performance of the supply chain and financial performance of the company. The tool used in this research is Microsoft Windows 7 operating system and software for data processing is Ms. Excel.

3.2   Research Procedures

In this study, there are several stages of research procedures undertaken to ensure achievement of maximum results and easy to implement. The stages of the research procedure start from the preparation stage and then proceed with the stages of data processing.

The preparatory stage begins with determining the location of the survey. Determining the location of the survey conducted in restaurants that are assumed to produce a large amount of food waste. After determining the location of the survey, the next stage is to make a questionnaire. Questionnaires were made with the aim of being the primary tool in the process of collecting data in the field. Questions in the questionnaire were made in accordance with AHP rules and with as simple as possible so that respondents could easily grasp

the intent of the question in the questionnaire. The third step is to plan the schedule. Planning a schedule is a very important step to the process of the survey from start to finish in accordance with the plan. After the previous stages have been done well, the final step is to conduct an interview.

Next is the stages of data processing. In this process the data obtained from the survey results will be processed using the AHP method and using Ms. Excel as a tool for data processing, then the results of data processing is then presented into the form table.
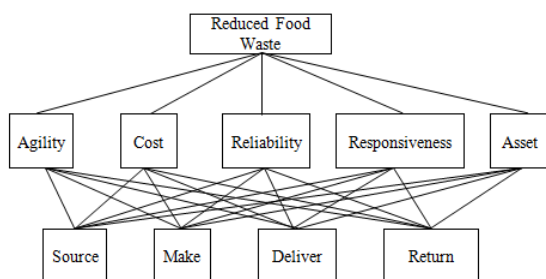

Figure 1. AHP Framework

4 Results and Findings

4.1 Results of Sub Criteria Research

In AHP research there are criteria and sub criteria tested. After the research, the results of research sub criteria are obtained as follows:

Table 1. Pairwise Comparison Matrix of Sub Criteria

CRITERIA	Source	Deliver	Make	Return	Priority Vector
Source	1.00	0.20	3.00	3.00	0.20
Deliver	5.00	1.00	6.00	7.00	0.63
Make	0.33	0.17	1.00	2.00	0.10
Return	0.33	0.14	0.50	1.00	0.07
Total	6.67	1.51	10.50	13.00	1.00

Based on the above table, it can be seen that in sub criteria deliver more dominant in donating food waste with priority vector 0.63, followed by source 0.20, make 0.10 and return 0.07.

4.2 Research Results Criteria

In this study obtained the following criteria:

Table 2. Pairwise Comparison Matrix of Criteria

CRITERIA	Cost	Responsiveness	Reliability	Agility	Asset	Priority Vector
Cost	1.00	5.00	4.00	6.00	5.00	0.50
Responsiveness	0.20	1.00	3.00	2.00	4.00	0.20
Reliability	0.25	0.33	1.00	3.00	3.00	0.15
Agility	0.17	0.50	0.33	1.00	3.00	0.09
Asset	0.20	0.25	0.33	0.33	1.00	0.05
Total	1.82	7.08	8.67	12.33	16.00	1.00

Based on the above table, it can be seen that in the criteria cost more dominates with the priority vector 0.50, followed by responsiveness 0.20, reliability 0.15, agility 0.09, and asset 0.05.

4.3 Discussion

[8] Basically food wastage occurs at all levels of the food supply chain. Products that are in the hands of end consumers have travelled a long way, the product is transported, refrigerated, heated, processed, altered, traded, treated and packed. Ultimately, the product does not just change shape, but most of the product has become food waste in the process [11]. Based on the results of research presented in the table above, it can be seen that the process of food waste due to the criteria and sub criteria. Sub-criteria criteria are source, make, deliver, and return. While the criteria are reliability, responsiveness, agility, cost and asset. After doing the research, sub criteria that dominates the formation of food waste is sub criteria deliver, then followed by sub criteria make, source and return. However, Gustavsson et.al. [12] found out that source of procurement is the most influential sub-criteria for food waste. For criteria, the dominant criteria are cost, responsiveness, reliability, agility, and asset. Other research results say that what has a direct impact is the practice of supply chain management itself [12].

Sub deliverable criteria (deliver) is an activity delivering the results or products from the company to the consumer. Deliver also includes the activities of transportation or transportation of raw materials from the supplier to the restaurant or food industry. In the delivery process, there is a high probability of food inefficiency. This is due to inadequate transportation and infrastructure systems in Indonesia. For example, the transport of fruits and vegetables using an open car that causes the food spoilage rate to be higher. Thus, it can be

concluded that the deliverable sub criteria are the sub criteria that cause food inefficiency, in this case caused by the less supportive transport and infrastructure systems [12].

Costs in the green supply chain are all costs associated with all supply chain activities from upstream to downstream. Cost is a very big influence on the green supply chain, whether in the supply chain will result in a food efficiency or will occur inefficiency that resulted in food waste. This happens because if the producers lack the cost that affects all sub criteria. With minimal costs, manufacturers cannot carry out proper packaging, good transportation, purchase of quality raw materials and cannot improve all facilities related to green supply chain resulting in food inefficiency resulting in food waste [12]. This shows that the cost criterion becomes the main source of inefficiency. However, there are studies have different results from reliability and asset that the dominant criterion causing the most influential food waste [11].

The second clitoris that affects the occurrence of food waste is the ability to catch due to errors in responding to consumer demand will affect the high volume of food waste that is the source of food waste. After that, the criterion that affects food waste is durability. This criterion can affect the amount of food waste if the raw materials used cannot last long to be stored, such as vegetables. Similarly, food products can easily become garbage when the implementation of quality system supervision process in the food industry is not going well. These results are in common with studies suggesting that there are natural factors related to the nature of a food that can not last long [11]. The criterion that influences the high volume of garbage next is agility because with the hasty process of adjustment to the tastes of consumers, will allow the mistakes that cause food waste. Furthermore, the criteria affecting the high volume of food waste is the asset, lack of assets owned by the company will have a major impact on the production process due to the inability to apply technologies that require high investment and can reduce the amount of waste generated during the production process.

5. Conclusion

Based on the results of hierarchical analysis of the process, it can be concluded several things, the first decision-making in reducing food waste is very complex, because it involves several entities that have different roles and functions from upstream to downstream. Then, the result of analysis shows that sub delivery criteria is the most dominant sub criterion in influencing food waste reduction and cost is a criterion that has big impact on green supply management hierarchy structure in reducing food waste.

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