

Study of Behavioral Changes in Efforts to Mitigate the Generation and Carbon Footprint of Food Waste from Lodging and Culinary Businesses in the City of Semarang

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Abstract: Food waste is a type of waste that has an enormous generation potential. The Ministry of Environment and Forestry (KLHK) through The National Waste Management Information System (SIPSN) released that in 2022 waste generation reached 18,826,763.61 (tons/year) with a food waste composition reaching 41.3%. The large amount of food waste generated creates the potential for quite serious problems if it is not handled immediately and properly. This research aims to analyze the amount of greenhouse gas (GHG) emissions in the form of carbon (CO₂) based on waste generation calculations from the Hotel and Restaurant sector in the city of Semarang in 2022. Problems arise when the existing potential for waste generation cannot be handled optimally, so an in-depth study is needed as one of the influencing factors, including changes in the behavior of economic actors as an important study in mitigation efforts. To achieve this goal, research was carried out using a mix methods of quantitative and qualitative methods using a literature database from the Semarang Satu Data Portal page and a literature review of behavioral change. The existing data is inventoried and the potential for waste generation is calculated, after which the conversion of waste generation into Green House Gas carbon is calculated. Furthermore, a qualitative study was also carried out regarding mitigation efforts in terms of behavior change interventions. The results are data on the potential magnitude of food waste generation in accommodation and culinary businesses in Semarang City as well as the GHG Carbon Footprint in 2022 and a study of changes in the behavior of economic actors as mitigation steps.

Keywords: *behavior; culinary; food; Lodging; Semarang; waste*

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1. Introduction

Solid waste, popularly known as rubbish, is goods or substances left over from daily human consumptive activities in solid form whose value and usefulness have been reduced. In everyday life, waste is often found in 2 (two) types, i.e., the organic which comes from living objects or substances that can be synthesized by nature, and the inorganic waste which comes from objects or substances other than living or artificial objects. Food waste is one of the types of waste with the highest potential for generation or accumulation. The Ministry of Environment and Forestry of Indonesia (Kementerian Lingkungan Hidup & Kehutanan Republik Indonesia) through the national waste management information system (SIPSN) page released that waste piles in 2022 reached 18,826,763.61 tons/year with the composition of food waste reaching 41.3%, followed by plastic waste at 18.6%, and wood waste reached 12.4% (SIPSN, 2022). These data seem to show that food waste generation is very dominant when compared to the composition of other wastes.

The dominance of food waste is inevitable considering its nature as a major part of the human needs cycle which can be found in all sectors, from the household, industrial, to tourism sectors. Hotels and restaurants are part of the tourism industry sector which also has the potential for generating quite high levels of food waste. This is because the provision of food is something that cannot be separated from the tourism support services industry. The city of Semarang itself is one of the metropolitan cities that has a fairly high level of tourism growth, especially as we approach the new year 2023, it is estimated that accommodation occupancy, both hotels and other accommodations, as well as the culinary business in Semarang City will reach 100%, which also indicates a positive trend on the growth of hotels and restaurants in 2023 (Puspa, 2022). This high potential is also a driving factor for the rapid growth of hotel and restaurant services.

The large potential for food waste generation from the hotel and restaurant sector in the city of Semarang is certainly an urgent problem that needs to be addressed immediately. This is of course faced to the increasingly decreasing capacity of the Jatibarang final processing site (TPA) in Semarang City (Semarang City Government, 2021). This problem is not resolved as the food production cycle which starts from the supply of commodity ingredients, the processing process, to consumption and remaining consumption requires quite a high use of energy resources, so this cycle also has the potential to generate greenhouse gases (GHG) emissions in the form of carbon dioxide (CO₂). GHG carbon emissions themselves are a term for various waste substances that will cumulatively become pollutants that cause global warming and climate change. Among several types of pollutants are hydrocarbons (HC), nitrogen oxides (NO_x), and carbon monoxide (CO) (Ismail, 2022).

The methodology that will be used in this research is quantitative and qualitative. The quantitative method is used to calculate the potential for waste generation in the hotel and restaurant sector. In the literature review, several research results were found that focused on this matter, including publications written by Hanjaya Saputra, et al. (Siaputra et al., 2019) entitled "Analysis of the Implementation of Food Waste Management at Restaurant 'X' Surabaya". This research produced data on the average generation of food waste at a hotel in Surabaya, i.e. 7.7 kg/day. The average figure in this research will be used as a coefficient value which will be multiplied by data on the number of accommodation and culinary businesses to obtain estimated data on the potential for waste generation in hotels and restaurants in Semarang City. Apart from that, the calculation of the carbon footprint from food waste generation

that will be carried out in this research will be an important additional element that has not been done before.

In addition to calculating waste generation and carbon conversion, it is also important to carry out mitigation studies. Many factors are the reasons why the handling of food waste in various places does not work optimally. A factor that is quite important to discuss is human behavior which is the main actor in economic activities. A behavioral change intervention is a coordinated set of activities and techniques introduced at a specific time and place to change the behavior of individuals, communities, and/or populations through hypothesized or known mechanisms. (Araújo-Soares et al., 2019). To analyze this, a qualitative method was used by interrelating the study of behavior change interventions with government regulatory documents, as well as existing practices.

From the various important things above, this research will try to answer two important questions, including 1) What is the potential for food waste generation and GHG emissions from food waste in the lodging and culinary sectors in Semarang City? and 2) how to study changes in behavior in efforts to mitigate waste generation food in the accommodation and culinary business sector in Semarang City? Thus, the outline of the idea of this research is to explore the interrelation between the potential for food waste generation and the conversion of GHG carbon emissions which can influence climate change, with strategic efforts to encourage changes in the behavior of economic actors that are already underway. Through the results of this research, it is expected that it will provide important data contributions for all parties in developing food waste management efforts.

2. Materials and Method

To answer the two main questions in this research, a mixed method of quantitative and qualitative, were used. Quantitative methods are used to explain the calculation of the potential for food waste generation, along with the conversion of GHG emissions produced, while qualitative methods are used to review how behavioral change factors can be an important study in efforts to mitigate the potential for waste generation and the threat of GHG carbon emissions.

The method used in this research is an applied quantitative research method. To extract data on food waste generation, a method of calculating waste directly from the source is used, namely data on the growth of lodging and culinary business units in the city of Semarang multiplied by the coefficient of the average data on waste generation obtained. from research so that the calculation formula is:

$$WG = HS \times Coefficient$$

WG	: Waste Generation (Kg)
HS	: Household (House, business unit)
Coefficient	: Multiplier factor (average restaurant waste generation,
Coefficient	: 7.7 (Siaputra et al., 2019))

The data obtained calculated the potential for waste generation. After obtaining data on food waste generation, it was then continued with carbon (CO₂) conversion, using the 2006 Intergovernmental Panel Climate Change (IPCC) standard calculation formula(Azizah et al., 2017):

$$ECO_2 = WG \times EF$$

ECO₂ : Carbon dioxide (CO₂) emissions
 WG : Waste Generation (Kg)
 EF : Emission Factor (FE uses FE in Mixed Waste, default 0,427 Kg CO₂ (Oja et al., 2019)

The two calculation methods were then formulated in one Excel calculation table to determine waste accumulation and conversion of GHG carbon emissions from each sample (hotels and restaurants).

The data that will be calculated using these two formulas is as follows:

Table 1. Lodging and Culinary Business Data

No	Year	Number of Hotels	No	Year	Number of Hotels
Hotels			Cafés		
1	2018-2019	136	1	2018	95
2	2020	169	2	2019	115
3	2021	182	3	2020	145
4	2022	186	4	2021-2022	169
Other accommodation			Canteens		
1	2018	0	1	2018-2022	875
2	2019-2021	305	Stalls		
3	2022	219	1	2018-2022	390
Restaurants			Coffee Shop		
1	2018	187	1	2018-2022	127
2	2019	190	Bars		
3	2020	215	1	2018	108
4	2021	1.568	2	2019	118
5	2022	1.675	3	2020-2021	121
			4	2022	43

The second step, a behavioral change study was carried out using qualitative methods in several book literature and the Semarang City Government Law regarding waste management. The results of the analysis are then presented descriptively in the form of steps to mitigate changes in the behavior of economic actors.

By using this method, we will obtain an overview of potential data on the generation and conversion of GHG carbon emissions, as well as their interrelation with the behavior change strategy carried out by the Semarang city government.

3. Result and Discussion

3.1. Potential generation and conversion of GHG carbon emissions from food waste in accommodation and culinary delights in the city of Semarang

The accommodation and culinary business is an industry that provides services to fulfill accommodation and consumption needs which cannot be separated from the tourism support sector. As the capital of Central Java Province, Semarang City has growth dynamics that also influence the existence of these sectors. These dynamics

can be mapped into a timeline before, during, and after the pandemic starting from the last 5 years, namely 2018-2022. This data can be seen from the Semarang One Data port on the link: data.semarangkota.go.id, with data divided into 1) the lodging sector including hotels and other accommodation, and 2) the culinary sector including restaurants, stalls, canteens, cafés, coffee shop, as well as bars (Semarang, 2022). Based on this information, data processing and analysis are then carried out to obtain data on food waste generation and conversion in the form of GHG carbon emissions. The waste generation in the accommodation and culinary business in Semarang City along with GHG carbon emissions in 2018-2022 is as follows:

Table 2. Amount of food waste and CO₂ carbon emissions

No	Year	Number of Hotels	Coefficient (Kg/Day)	Amount of Food Waste (Kg/day)	Emission Factors	Food Waste Carbon Footprint (Kg/Day)
hotels						
1	2018-2019	136	7,7	1047,2	0,427	447,1544
2	2020	169	7,7	1301,3	0,427	555,6551
3	2021	182	7,7	1401,4	0,427	598,3978
4	2022	186	7,7	1432,2	0,427	611,5494
other accommodation						
1	2018	0	7,7	0	0,427	0
2	2019-2021	305	7,7	2348,5	0,427	1002,81
3	2022	219	7,7	1686,3	0,427	720,0501
restaurants						
1	2018	187	7,7	1439,9	0,427	614,8373
2	2019	190	7,7	1463	0,427	624,701
3	2020	215	7,7	1655,5	0,427	706,8985
4	2021	1.568	7,7	12073,6	0,427	5155,427
5	2022	1.675	7,7	12897,5	0,427	5507,233
cafés						
1	2018	95	7,7	731,5	0,427	312,3505
2	2019	115	7,7	885,5	0,427	378,1085
3	2020	145	7,7	1116,5	0,427	476,7455
4	2021-2022	169	7,7	1301,3	0,427	555,6551
canteens						
1	2018-2022	875	7,7	6737,5	0,427	2876,913
stalls						
1	2018-2022	390	7,7	3003	0,427	1282,281
coffee Shop						
1	2018-2022	127	7,7	977,9	0,427	417,5633
bars						
1	2018	108	7,7	831,6	0,427	355,0932
2	2019	118	7,7	908,6	0,427	387,9722
3	2020-2021	121	7,7	931,7	0,427	397,8359
5	2022	43	7,7	331,1	0,427	141,3797

Based on data in Table 2, data analysis is then carried out to determine the average unit growth for each sector, the increase in food waste generation, and the increase in GHG carbon emissions. This is shown in the following Table 3:

Table 3. Sector growth, waste generation, and GHG carbon emissions

Sector	Average Growth of the business sector in 2018-2022 (units/year)	Average increase in food waste in 2018-2022 (Kg/Day)	Average Increase in GHG carbon Emissions in 2018-2022 (Increase in Waste X FE *0.427) (CO ₂ Unit kg/day)
Hotels	10	77	32,879
other accommodation	-17,2	337,26	144,01002
restaurants	297	2291,52	978,47904
stalls	0	0	0
Cafés	10,8	113,96	48,66092
canteens	0	0	0
coffee Shop	0	0	0
Bars	-15	-100,1	-42,7427

From the Table 3, it can be shown that the lodging and culinary business sector is experiencing dynamic growth from 2018-2022. This is also accompanied by the growth rate of waste generation, as well as the GHG carbon emissions released. This is illustrated through the following Figure 1.

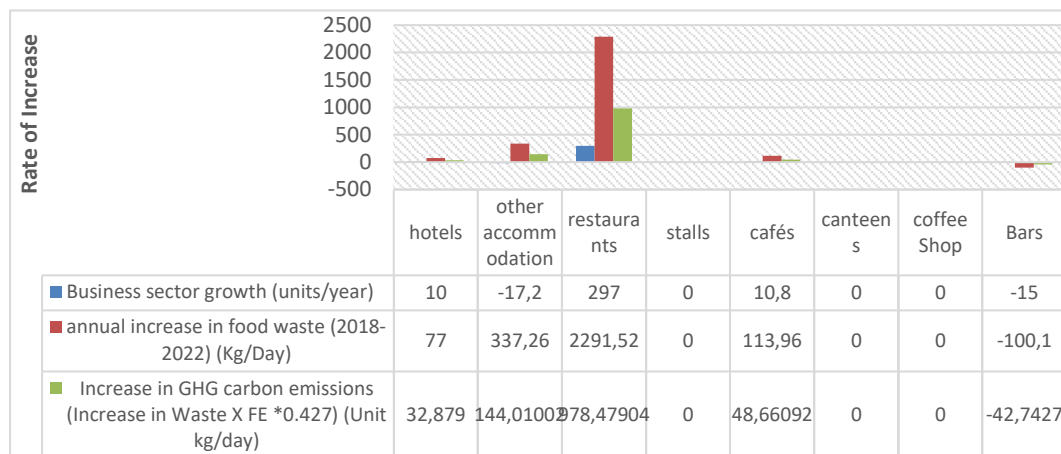


Figure 1. Graph of business unit growth, food waste generation, and GHG carbon emissions

The graph shows the trend or trend in business unit growth rates, waste generation, and GHG carbon emissions. The dynamics of growth in sequence from increasing, stagnant, to decreasing are those that have increased: 1) Restaurants, 2) Cafés, 3) Hotels, 4) Other accommodation, experiencing stagnation or remaining 5) stalls, 6) Canteens, 7) Coffee Shop, which experienced a decline was 8) Bar.

3.2. Efforts to Reduce the Potential for Food Waste Generation Through Mitigating Behavioral Changes

Food waste is one of the types of waste that occupies the first position compared to other types of waste. The amount of data obtained from exposure to food waste generation and GHG carbon conversion in the accommodation and culinary business sector seems to confirm this condition. From the Figure 1 above, it can be seen that the dynamics of waste generation are dominated by a trend or increasing tendency, in fact, of all the existing units, only the Bar unit shows a decreasing trend in waste generation and GHG carbon emissions. Meanwhile, what is quite interesting is also found in other lodging unit sectors, although the growth of business units has decreased by an average of -17.2 units per year, the increase in food waste and GHG carbon has increased by 337.26 Kg/day and 144.01002 CO₂ Kg/day. This shows that there is non-linearity in growth potential, making it possible to find behavioral factors of producers and consumers in the food cycle. This also shows the need for appropriate, structured, systematic, and massive mitigation measures to reduce food waste generation.

Regarding the economy and business, especially the accommodation and culinary sectors, Ajit Bhalla (2001) in his book entitled *Market or Government Failures? From an Asian Perspective*, the dynamics of the effects of environmental damage are closely related to the behavior of economic actors in carrying out production-consumption activities as the main economic activity. So, it can be concluded that one of the mitigation efforts in reducing the generation of food waste is to intervene in changing the behavior of producers and consumers. According to Fishbein, M., & Ajzen, I (2007). in the book entitled *Predicting and Changing Behavior: The Reasoned Action Approach*, it is stated that the reasoned action approach can help in predicting and changing individual behavior. This approach emphasizes the importance of cognitive and affective factors in influencing behavior and provides an overview of how persuasion and facilitation instruments can be applied in behavior change efforts (Gold, 2011). Cognitive and affective change efforts can technically be demonstrated through persuasion, facilitation, and implementation of sanctions and rewards (law) (Mahendra et al., 2019). A general description of this strategy is as the following.

1. Persuasion Strategy

Persuasion is a strategy for changing behavior that is carried out by providing information, understanding, and support to individuals or groups that they are encouraged to make the desired behavioral change. Examples of the application of persuasion in efforts to overcome food waste generation are: 1) Socialization about the importance of reducing food waste generation, either through social media, brochures, posters, or campaigns; 2) Providing information on how to sort and manage food waste correctly and in an environmentally friendly manner, through training or guidance.

The Semarang City government itself has a community-based household waste management program by organizing community groups in the 3R Integrated Waste Processing Site and Waste Bank, this is based on the Semarang City Government Regulation. Semarang City Regional Regulation Number 6 of 2012 concerning waste management states that residential area managers, commercial areas, industrial areas, special areas, public facilities, social facilities, and/or other facilities are required to provide infrastructure for storage, collection, and TPS including waste sorting (Peraturan Daerah Kota Semarang Nomor 6 Tahun 2012 Tentang Pengelolaan Sampah, 2013). Through the Waste Bank, there are many opportunities for persuasion

efforts to build the community's understanding and capacity in managing their waste. Based on data from the Semarang City Environmental Service, it is known that Semarang City has many TPS and Waste Bank units spread across many sub-districts, but the problem is that not all of these Waste Banks are active in providing services, and education to the community. This is what the Semarang City government needs to pay attention to to increase the activities and role of the existing Waste Bank, especially in providing waste management education to the community as a form of persuasion. Apart from that, the Waste Bank in Semarang City as a whole only accommodates waste originating from households, while there is not much of it in the lodging and tourism business sector or even none.

2. Facilitation Strategy

Facilitation is a behavioral change strategy that provides support and convenience for individuals or groups to make the desired behavioral changes. Examples of implementing facilitation in efforts to overcome food waste generation are: 1) Providing appropriate and easily accessible trash containers or bags. 2) Increase access and use of food waste composting or recycling systems. 3) Establish a waste bank to collect food waste and provide incentives or prizes for those who collect food waste.

The city of Semarang already has waste management facilities starting from landfill and TPS facilities as well as transportation facilities. However, not all of these facilities are in good condition and support waste management efforts. The Jatibarang landfill, which is the main waste processing facility in the city of Semarang, is known to be in a condition of excess capacity and should have been closed in 2021 (Annizar, 2023). Apart from that, waste that is not properly sorted is also the cause, influenced by transportation factors that do not support sorting. Food waste, which is easier to process because it is dominated by organic types, becomes difficult to process because it is mixed with inorganic waste. This is something that needs to be reviewed again by the government so that the existing facilities are not only complete in terms of quantity but also quality in providing services so that they can encourage changes in people's behavior.

3. Laws and Statutes

Sanctions and appreciation (law) are strategies of behavioral change that provide consequences for what is done. These consequences can be in the form of punishments or rewards, appreciation for individuals or groups who do not comply with the rules or do not make desired changes in behavior, and also for individuals who carry out and help enforce the rules. Examples of applying sanctions and rewards in efforts to overcome food waste generation are: 1) Providing fines or administrative sanctions for business actors who do not comply with food waste management regulations, 2) Revoke business permits for business actors who continuously violate food waste management regulations, 3) Provide social sanctions or stigma for individuals or groups who do not comply with food waste management rules, 4) Providing appreciation or recognition for individuals or groups who have succeeded in reducing the generation of food waste in the form of prizes compensation and incentives.

Legal regulations containing sanctions and rewards in waste management activities in the city of Semarang itself have been contained in the Semarang Mayor Regulation Number 79 of 2018 concerning Regional Policies and Strategies in the Management of Household Waste and Similar Types of Household Waste. It is stated that the Regional

Government of the City of Semarang will establish and implement a disincentive system for area managers who do not manage area-based household waste and household-like waste through sorting, collection, and transportation activities (Peraturan Walikota Semarang Nomor 79 Tahun 2018, 2018). This is a form of sanction for those who do not manage their waste well, as well as appreciation for those who succeed in managing their waste. However, the issue of law enforcement or Law enforcement is an important thing to review so that existing sanctions and appreciation can be properly enforced, so that they can encourage changes in behavior in society.

4. Conclusions

Food waste is an urgent problem that needs to be addressed immediately. This can be seen from the calculation results of the potential for waste generation which shows a trend or tendency to increase, in line with the rate of business growth in the lodging and culinary sectors. The results of data analysis on food waste generation from the lodging and culinary business sector in the city of Semarang itself show that only the Bar business unit shows a downward trend in terms of business unit growth, food waste generation, and GHG carbon emissions. Meanwhile, the other 7 sectors are on a trend of increasing to stagnant or constant.

The existence of this trend indicates the need for mitigation efforts in the form of behavior change interventions for business actors or producers, as well as customers or consumers. Efforts to change behavior can be achieved using instruments of persuasion, facilitation, and the application of sanctions and appreciation. The city of Semarang already has several things that are included in the behavior change instrument, but several things make it less than optimal, so it is important to review it again.

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