Original Research

Household Food Waste in Indonesia: Macro Analysis

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Abstract

The aim of this research is to examine the relationships between household food waste generation and its determinant Provincial level in Indonesia. The panel data are collected from 2019-2020 based on various sources which are the National Waste Management Information System (SIPSN), the Central Bureau of Statistic, and the jdihn.go.id website. The determinants of variables used consist of economic, socio-demographic, and governmental factors. Economic factors are represented by variables of per capita income. Meanwhile, the socio-demographic factors used are the number of populations, school participation rate, the amount of managed waste achievements for composting. Governmental factors conduct variable of regulations in managing household waste. The results of using panel regression showed that the variables which affect the household food waste are the level of per capita income, the number of populations, and school participation rate.

Keywords: household, food waste, determinant, provincial level, Indonesia JEL: Q53, Q56

Introduction

Food waste is a global problem that needs to be addressed as part of the steps to achieve sustainability. The term 'food waste' refers to the reduction in food quantity or quality resulting from decisions and actions made by retailers, food service providers, and consumers [1]. The UN Sustainable Development Goal of halving food waste by 2030. The aim of The Sustainable Development Goals (SDGs) is to build more sustainable future for community and individual global ecosystem. It is explicitly stated in SDGs 12 that targeted to halve per capita global food waste at the retail and consumer levels, and substantially reduce waste generation through prevention, reduction, recycling, and reuse [2].

This waste is a concern because it has a prodigious negative impact on the global economy, food availability, and the environment. According to FAO, approximately one-third of all food produced for human consumption is wasted or not consumed as it should be (wasted). The total value of food waste is 1.3 billion tons or 990 billion USD. This amount of food is enough to feed one-eighth of the world's population who suffers from hunger [1, 3]. The percentage is around eight to ten percent of global greenhouse gas emissions attributed to food that is not consumed [4] .

Food waste also burdens waste management systems, exacerbates food insecurity, and makes it one

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of the main contributors to environmental problems such as climate change, loss of nature and biodiversity, pollution and waste [3, 5, 6]. Furthermore, in the landfill site, food waste turns into methane which is a type of greenhouse gas that causes global warming with a potential 25 times higher than carbon dioxide [7]. This state indirectly contributes to the destruction of environmental resources and the loss of social well-being. Economically, FAO defines food waste as economic waste since food that is produced but not consumed has a yearly global mass trade value of USD 936 billion [8] .

Food waste is able to occur in every process of the food production chain (food supply chain). Food is wasted and lost mostly in later stages of the supply chain in middle and high-income nations. The behavior of consumers plays a huge part [9]. Nevertheless, emerging economies are increasingly confronted with this issue. Income growth, demographic and cultural trends over the last few decades have resulted in changes in eating patterns, which frequently value convenience.

Food waste accounts for over a quarter of all waste in Asia, particularly in South and Southeast Asia [10]. Meanwhile, Indonesia is the 17th largest contributor to the global food waste [4]. This result is particularly paradoxical given Indonesia's ranking of 70th out of 117 nations with severe hunger. From 2016 to 2018 times frame, 22 million Indonesians were still suffering from hunger [11]. According to FAO, household food waste in Indonesia is 77 kg per inhabitant per year or 20,938,252 tons per year [4]. Based on the information presented in the National Waste Management Information System (SIPSN), the largest composition of waste based on its type is food waste (around 40 percent), while based on the source is dominated by households [12].

Indonesia has adopted the circular economy concept and elaborated the concept in making policy. Circular economy is a closed loop economic system strategy in which raw materials, components, and products are kept as usable and valuable as possible in order to limit the quantity of waste material that is not reused and then disposed away in a landfill site [12]. The circular economy itself is an instrument to achieve sustainable development. The successful transition to a circular economy is predicted to help reducing waste generation. This waste reduction depends on five significant sectors, one of them comes from a decrease in food loss and waste [13]. Given the importance of addressing Indonesia's food waste problems, understanding food waste drivers and behaviors is then utilized to give insight into the best policy measurement for managing food waste in a sustainable manner. Food waste prevention policies are considered in the context of the waste-generating behaviors and attitudes that they target.

However, the previous studies are using cross-countries data that are not specific to address one country [3, 14]. Another study in Indonesia also focuses on the household level in one area [15]. Moreover, based on our opinion, empirical research on the determination of food waste on regional or macroeconomic levels focusing on only one country is really rare or uncommon. Indonesia is a country with multicultural and heterogeneous backgrounds, and also one of the most populated countries in the world. This makes Indonesia to be one of the highest contributors to food waste in the past recent years. The research studies on Indonesia related to food waste are only on the individual levels [16]. Some studies only focus on formal wastes and exclude wastes that escape through pathways other than the traditional waste management systems, for example composting [7]. The factors that influence household food waste have been extensively studied at both the micro and macro levels. To ascertain the effect of household behavior and socioeconomic conditions on food waste generation, studies in Indonesia currently place a lot of emphasis on the use of micro data as in household surveys. No one has specifically used inter-provincial data in a macro analysis. Based on the limitations of the previous studies and the gap, the present studies intend to examine the determinant of household food waste on the regional level by using macro analysis, based on socio-economics, regulatory and waste awareness factors.

The rest of this paper is organized as follows. Section two provides a discussion of the literature. Section three shows the outlines of the materials and methods. Sections four and five provide the results and discussion. Section six is the conclusion.

Reviews

Discussing the food system, improving food and nutrition security, and contributing to environmental sustainability are all inextricably linked on how to decrease food loss and waste. Essentially, the two expressions refer to food that is discarded without being consumed or food wastage [17]. Food wastage happens at every stage of the supply chain, with 35 percent happening at the level of final consumption. It varies greatly between nations according to mostly affluence, industrialization, and developmental levels [3]. Food losses are empirically defined as occurring along the food supply chain from harvest/slaughter/catch to, but not including, the retail level. Food waste, on the other hand, happens at the retail and consumption levels [1].

The research studies on food waste are focusing on this matter due to the essential impact of climate change. The consumer's perspective explains the motivation of consumers to reduce food waste at individual level [18-20], and household levels [21-28]. Generally, the determinant of food waste can be classified based on internal and external factors. The internal factor is the factor that relies on and motivates a person to make organic and non-organic waste. The first internal factor is the people's decision for buying groceries or eating out. It can be determined by shopping or meal plan, the diet of the household, and the behavior in order

to reuse the leftover routines. However, the external factor can also determine by how much foods waste generates from each individual outside of themselves. According to [26], the main external factor of people wasting their food is because of their impulsive behavior. In the case of Greece and Spain, the promotional intensive shopping and eating out behavior may significantly increase the food waste in the two observed countries. Other studies found out that different education and professional background also play an essential role to this issue [18]. Higher education would lead to increase the awareness among customers to not buy more than what they can consume. In addition, well-educated people are more familiar with meal preparation, nutrition and stock management [7, 29]. However, the majority of the studies also includes the socio-economics variables such as demographic [19, 30], cultures and attitudes, knowledge and economic situation [20, 31]. The cultures and attitudes are able to create food waste only because it is considered as non-consumable [20]. In addition, some researchers also confirmed that environmental awareness and financial literacy could be one of the driven factors for food waste [28, 32-34].

On the other hand, there are limited number of researchers focusing on food waste on regional and national level of countries. Since the Sustainable Development Goals has been published, food waste become social problem that needs to be solved seriously. By utilizing 44 cross-countries data and only focus on macroeconomic variables [3] successfully revealed that population, national income, economic incentives and awareness are the determinant of household to create more food waste [3]. Other studies focusing on the hospitality and food retails in the North America, Europe, Asia and Oceania also found the same result [35]. In the two previous studies revealed that the legislation about food waste reduction on specific sector especially on hospitality, restaurant and agriculture could be statistically significant to influence reducing food waste in the observed countries. However, the author cannot ignore the level of environmental awareness and the incentives for reducing food waste.

Methodology

Data

This study aims to examine the determinant of household food waste on the regional level based on economic, socio-demographic, regulatory and awareness factors. The study area is in Indonesia provincial administrative regions from 2019 to 2020. In this study, provincial panel data was used to analyze the relationships between food waste generation and determining factors. Because of the missing data for North Maluku, West Nusa Tenggara, East Nusa Tenggara, and West Papua, it was excluded from this

study. Therefore, there were 30 provinces selected. All the variables involved in this paper are described in the following:

Dependent Variable:

Household Food Waste Generation

Since the second major food waste problem is at the consumer end of the chain [8, 36], this study limits food waste to the final consumption only at the household level. The sources of household waste in question include housing and residential areas. Meanwhile, information regarding to the composition of waste was obtained from the facility waste such as temporary shelter; temporary shelter for reduce, reuse, and recycle; integrated waste management shelter; Intermediate Transition Station; Garbage Bank; Compost House; and/or facilities other types of waste [37]. Due to limitation of data, the quantity of food waste in this study is mainly for food leftovers in the organic form, wrapped either in the form of paper, plastic, or rubber are excluded.

The waste generation data used is an annual household food waste in kilograms per capita (kg/year) provided by The National Waste Management Information System (SIPSN). Throughout out Indonesia, SIPSN collects waste data at the district or city level. Data collection began in 2018 and continued to 2021. However, not all districts or cities report their waste data every year. As a result, the researcher made several adjustments to the waste data:

A. Because there are so few regions reporting in 2018 and 2021, the years used are only from 2019 to 2020.

B. Not all regions or cities in each province reported consistently over a two-year period, the inconsistent regions were excluded from each province's calculations.

C. Furthermore, data on the percentage of food waste for vacant regencies/cities is not included in the calculations.

D. The value of household food waste per province is calculated by adding the amount of district/city household food waste in each province, where the data comes from the value of the proportion of food waste multiplied by the amount of household waste.

Independent Variables:

Economic-Demographic Variables

Food waste is not only related to social and economic factors but also on dynamics in population, habits and lifestyle that are non-readily changeable [38]. Food waste may occur due to shopping habits, with a common cause of food waste being simply over-buying of food that later remains unused and discarded [25]. Per capita income at constant prices is used to reflect the economic status and wealth. From a demographic point of view,

total population is used as a proxy for population size [3], indicating the number of purchased food and size of final consumption [39]. Data for both variables used in this scope are from the Indonesian Central Bureau of Statistics.

Legislation

Although the influence of policies on food waste generation is a complicated process. The presence of regulations and legislation is supposed to be able to advocate and even force a strategy to be adopted to reduce food or even take preventive measures. The regulation would increase awareness and mobilize institutional attempts to formulate and unify the regulated strategy by statutory regulations [3]. The regulatory approaches typically include waste reduction objectives such as laws and standards, management plans, restrictions, or agreements that aim to encourage waste reduction and preventive behavior through penalties for offenders who fail to comply with the provisions of the regulations [40].

The issuance of Presidential Regulation No. 97 of 2017 Concerning Policy and National Strategy for Management of Household Waste and Waste Like Household Waste is also well-known as Jakstranas. Demonstrating the seriousness, Indonesian government is approaching the issue of national waste, particularly on domestic waste. Jakstranas includes strategies, programs, and reduction targets for the years from 2017 to 2025, as well as policy directions for handling household waste and waste that resembles household waste. Based on this construction, the provincial Governor of Jakstranas Regulation is used as legislative variable. Regional commitments are represented by a dummy variable that sets to 1 for regions that have established Jakstranas and 0 for regions that have not been established by Jakstranas. The information was obtained from the JDIHN.go.id website, a national network for legal documentation and information.

Education

The ability to adapt in a world that is constantly changing is a skill that education gives individuals and societies. Education has a substantial impact on people's ability to reconsider their lifestyles and behaviors that harm the environment by enhancing knowledge, fostering values, cultivating beliefs, and altering attitudes [41]. Higher educated individuals are more likely to support environmental protection policies through their actions as well as by taking pro-environment positions on political issues. In addition, effective governance requires an educated society [42].

The school enrollment rate (SPR) is used as a proxy for the education variable (data collected from BPS). SPR represents the proportion of the population of a certain school-age group who are currently attending school (regardless of the level of education attained)

to the population of the corresponding school-age group, where Non-Formal Education (Package A, Package B, and Package C) is taken into account. This figure is used to find out how many of the school-age population has used educational facilities. The SPR values range from 0 to 100. The higher means more school-age children attend school in an area.

Waste Awareness

Based on the waste hierarchy treatments for waste are reuse, recycling, another recovery and then disposal. In the context of food waste, recycling options in the form of composting is the best option to reduce food waste [43]. In this regard, this study adds the number of outcomes of organic waste processed by composting houses both centralized and home composting per capita (kg/year), where the data is obtained from The National Waste Management Information System (SIPSN).

Method

The empirical study considers a panel regression model with the following form Eq. (1):

$$lnfw\_hh\_cap_{it} = \beta_0 + \beta_1 \, lngdp_{it} + \beta_2 \, lnpop_{it}$$
$$+ \, \beta_3 \, legislation_{it} + \beta_4 \, spr_{it} + \beta_5 \, \text{lncompost\_cap} + \varepsilon_{it}$$
$$(1)$$

Where, *lnfw_hh_cap* is the natural logarithm of household food waste quantity per capita (kg/year), *lngdp* is the natural logarithm of per capita income at constant prices 2010 (IDR), *lnpop* the natural logarithm of total population (people), *legislation* is dummy variable, regions with regional regulations on household waste management are given the number 1 otherwise 0, *spr* is school participation rate (16-18 years old), *lncompost_cap* is the natural logarithm of total waste processed by centralized and home composting per capita (kg/year); β_0 denotes constant; $\beta_1 - \beta_5$ are respectively the coefficient of *lngdp, lnpop, legislation, spr and lncompost*; ε_{it} an error term; i denotes province i, and t denotes year t.

Panel data regression is the analytical technique that is used, and there are typically three models namely pooled least squares (PLS), fixed effect model (FEM), and random effect model (REM). Considering the presumptions of each techniques, the fixed effect model (FEM) is decided to be used. One is able to estimate a fixed effects model if we want to estimate group-specific intercepts without imposing a distribution or using data from the other groups [44]. Additionally, "time-varying explanatory variables" in this analysis refers to the fact that each x_{it} component varies over time for some units across sections [45]. If two conditions are met, it makes sense to use the fixed-effect model. Firstly, we believe that all of the studies included in the analysis are functionally identical. Secondly, rather than generalizing

to other populations, our objective is to compute the common effect size for the identified population [46].

Results and Discussion

Before estimating the model, the authors reviewed the data picture descriptively. Where the number of observations used was 60 observations from 30 provinces in Indonesia from 2019 to 2020. Table 1 shows that on the average household waste generation, food waste reaches 677.306 kg/year per province. Furthermore, the average per capita income of 4,510,000 rupiah, and the average population is 8.512.480 people per province. Up to 65% of provinces in Indonesia have regulations on policy directions for handling household waste. Regarding social variables in the form of education, 74.45% of the population aged 16 to 18 benefited from educational institutions. In addition, the average amount of waste processed into compost is 1.286 kg/year. A calculated mean value higher than the deviation indicates a deviation of the data. Thus, natural logarithm transformations are applied in the estimate to reduce the deviation.

Table 2 shows the empirical results of the Fixed Effect Model. Based on the partial t-test, the results showed that only the income and education variables have significant negative influence on the amount of food waste with coefficients of -2.062 and -0.440 respectively. While for the demographic variable, namely the number of populations, it has a statistically significant positive effect with a coefficient 10.07. That is, every 1 percent increase in per capita income decrease the amount of food waste by 2.062 percent and increase in school rate participation 1 unit decrease the amount of food waste by 0.440 percent. Then, 1 percent increasing in the population increases the amount of leftover food waste by 10.07 percent assuming the average and other variables are considered constant. The R-squared value of 0.273 means that 27.3 percent of the independent variables in the model were able to explain the dependent variables of the amount of food waste with the rest described by other variables outside the model.

Table 2. Empirical Result.

VARIABLES	*lnfw_hh_cap*
Lngdp	-2.062**
	(0.971)
Lnpop	10.07*
	(4.974)
Legislation	-0.0424
	(0.116)
Spr	-0.440**
	(0.191)
lncompost_cap	0.0619
	(0.0529)
Constant	-13.21
	(35.46)
Observations	60
Number of prop	30
R-squared	0.273

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Source: Authors, using research database

Income is the determinant indicator of the amount of household waste, as mentioned in the previous studies. Several studies show that a higher income level results in a higher amount of household waste [19, 35]. However, the estimation results of this research model show different results. The model estimate shows a negative relationships between income level and the amount of household waste. A reasonable explanation for this might be that individuals with higher incomes are more likely to have better food storage arrangements, which enable them to preserve food for longer periods of time [35], especially given that they have better access to private electricity generation in light frequent power outages that still happen in some districts in Indonesia. In this case, food waste occurs at the household level

Table 1. Descriptive Statistical Tests.

Variable	obs	Mean	Std. Dev	Min	Max
fw_hh_cap	60	677.306	1940.458	0.64	11691.38
gdp	60	4.51e+07	3.34e+07	1.67e+07	1.75e+08
pop	60	8512480	1.17e+07	695600	4.96e+07
legislation	60	0.65	0.4809947	0	1
spr	60	74.45183	6.189596	63.5	88.97
compost_cap	60	1285.999	3170.167	172813	23341.94

Source: Authors, using research database

as a result of inadequate or absent storage facilities for raw and cooked food in low-income households [47].

The population variable has positive influence on the amount of food waste in Indonesia. The results of this study are the same as macro analysis using cross-country levels which show an increase in the number of people increasing food waste [35]. The results of the study showed that the surge in food waste patterns exceeded the increase in the proportion of the population. Several similar studies employing micro data revealed that the only socio-demographic component shown to have a clear link with the amount of food left over was the number of inhabitants in the home. Naturally, household size has a direct association with the quantity of waste created per family. The more family members in a household, the more food is wasted [19, 20, 25]. Therefore, it is important to raise awareness of the importance of population control, especially on how much leftover food is produced in households [48].

The results of this study are also in accordance with previous research which stated that government regulations are less effective and significant in reducing food waste due to various complex types of food waste problems. The reduction goal of Jakstranas is to reduce existing waste production by 30%. However, not all regions actually directly implement the presidential regulation in their areas. Some regions in fact started developing their regional policies and strategies right after the presidential decree was published, but many of them are still in the planning stages and were not published for several years. Additionally, Jakstranas is the National Long-Term Development Plan and the National Medium-Term Development Plan, there has to be adequate time for these regulations to function consistently and effectively. Even though it is not statistically significant, the negative coefficient of this legislative variable indicates that, however consistently applied. The Jakstranas strategies and targets hope to significantly reduce the amount of food waste.

According to the estimation results, the lesser food waste is, the better the educational environment becomes because it is shown to be inversely correlated with the generation of food waste. A well-educated society is essential for effective governance. When power is decentralized to the local level, communities need to be educated to know their rights and allow them to influence decision-making [42]. Education is able to support sustainable development goals through at least two approaches. The former tends to focus on literacy retention or on specific knowledge to produce behavior changing. Education can also facilitate the changing in values, worldviews, and behaviors at the level of individuals, communities, and societies as a whole. For example, the idea of reducing food waste and energy consumption is important to sustainability and people might reduce food waste and save energy at home. The second approach focuses on developing agency, competence and participation, suggesting that education can facilitate self-reflection or critical learning,

acquisition of knowledge and skills, and greater agency to address complex sustainability issues, e.g., how to make environmentally friendly products [49].

To address the issue of organic waste in the form of food waste, which is unquestionably detrimental to the environment, a practical solution required. There are three methods existing for managing waste: reducing, reusing, and recycling. The use of the recycle technique, which transforms waste into something with use value or benefits, such as composting, is one of the most efficient methods for managing the final product of food waste. Composting technique is the combination of organic waste such as food waste, manure, husks, and compost seedlings with the right ratio and arranged according to the composition [50]. Although numerous studies have demonstrated that waste management with composting methods has been effective in managing food waste [50-52], this activity is typically not running continuously in Indonesia, as shown by the estimation results that they are not significant. It is caused by several factors including market failure, weak government support, inadequate technique used, and household behavior [53]. The level of awareness of households in sorting and processing waste is still at the low level. The results of a national economic survey revealed that as many as 66.8 percent of Indonesians still burn household waste without being sorted. Only 1.2 percent of households do the recycling process [54].

Conclusions

By using data from 30 provinces in Indonesia in this study, it can be concluded that the determinants of household waste in Indonesia are income, population, and education. Legislation variable is not considered to have a direct impact on household food waste generation and the estimation results showed is not significant. This may be due to two reasons. First, the time period used in the research is too short so that it cannot capture the effect of the policy on reducing the amount of food waste. Second, this indicates that policy and legislation related to waste, especially food waste, have not been effective in Indonesia and possibly needs sufficient time to be implemented. Furthermore, the level of waste awareness also has no effect on household food waste generation. These results also prove that the level of awareness of the Indonesian population is still low on the reprocessing of food waste.

This study brings evidence that can be used by the government in designing policies to reduce food waste in Indonesia. The government can formulate waste policies because currently there is no specific policy for household food waste. In addition, the government also is hoped to provide fiscal incentives to reduce food waste. Moreover, changing household behavior in waste management is very important to reduce food waste. Information campaigns to prevent food waste on social media and digital networks, training for waste

management at household level (composting) are some options that can be implemented to build people's awareness.

However, regarding the implication of the results of this study, there are some limitations that need to be considered. Firstly, in terms of data quality, the strength of the estimation results of this study is limited by differences in data sources and data length. A sufficiently long period may be able to capture the effects of several variables on the amount of food waste. Secondly, the results of the macro analysis in this study have the potential to ignore several micro aspects, such as household socio-economic characteristics, household behavior in processing food waste. Therefore, for further studies, it can be equipped with household-based data analysis so that it can be more comprehensive in explaining the problem of household waste. Furthermore, this study has focused on distinguishing the determinants of food waste. Once it has desired to forestall garbage by customers there is a need to understand reprove triggers will improve consumer's food consumption management. Thus, future analysis specializing in exploring such triggers can enrich this study and supply a lot of recommendations for policymakers for food waste reduction.

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Conflict of Interest

The authors declare no conflict of interest.

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