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Sustainability Life Cycle Assessment (LCA) Of Household Food Waste Management In Urban Areas during the CoVID-19 Pandemic[a1]

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ABSTRACT

Food waste is a very serious problem, it is proven that Indonesia is the second largest producer of food waste in the world. A limited waste management system will result in a decrease in environmental quality such as air pollution, water pollution, and soil pollution. So far, the waste management system is only limited to reducing waste generation. Life Cycle Assessment (LCA) is a systematic approach to identify, measure and analyze the environmental impacts of the entire recycling cycle[a2]. This study aims to produce[a3] an effective and environmentally friendly waste management strategy by considering environmental impacts so as to obtain sustainable household waste management and environmental sustainability. The design used in this research is cross sectional by conducting direct observations and interviews at the Waste Bank. Interviews were conducted to identify more in-depth about waste management problems and about the characteristics of respondents and waste characteristics. While observations were made to calculate waste generation that refers to SNI 19-3694-1994[a4]. The sampling technique was carried out by purposive sampling totaling 100 households[a5]. The results of research with organic waste processing with the Black Slodier Fly (BSF) method Organic waste processing with the Black Slodier Fly (BSF) method produces impacts on global warming, acidification, eutrophication and ozone layer depletion. Of the four impacts that produce the smallest impact is the impact of global warming of 0.281 kg CO2 eq compared to other impacts. However, BSF processing can reduce environmental impacts, especially global warming, and the factor of consumption patterns[a6] and education affects people's behavior in generating food waste so that there are policy recommendations for Waste Bank stakeholders in processing food waste.

Keywords: LCA, Food Waste, Household Waste Management, Economic Status

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1. Introduction

In developing world, urbanization is occurring rapidly as people from rural areas migrate to big cities for better job opportunities and a better lifestyle [1][2]. Increasing population density in the context of unplanned and unsustainable urbanization also challenges the accumulation of waste [3]. As a result, sanitation and hygiene for health are lacking. Sanitation and hygiene are essential for health and survival. Many countries are challenged in providing adequate sanitation for their entire population, putting people at risk of water, sanitation and hygiene (WASH)-related diseases. Worldwide an estimated 2.4 billion people lack basic sanitation (over 32% of the world's population) [4]. The man fund's decent drinking water access target in the 2020-2024 National Medium-Term Development Plan for access to decent drinking water is 100% and access to safe drinking water is 15%. Poor waste management can cause environmental quality to decline, causing surface water pollution, groundwater, air pollution. Food[a7] waste[a8] is food waste that has not been eaten and is discarded for various reasons and left to rot [5][6][7]. According to Papargyropoulos et al in the United States food waste such as milk, vegetables and fruit can increase 22% of greenhouse gases [8]. Some studies show that reducing food waste can have a beneficial impact on climate change [9].

The limitations of waste management make the waste management system uncontrollable. Public awareness and knowledge of sorting waste and processing waste is still very low. This is also due to the government's low attention to environmental conditions and community sanitation, causing a lot of waste to accumulate in landfills or TPSTs in the village. Therefore, there needs to be an approach from various aspects to determine a sustainable waste management system. Waste banks are one of the solutions to the waste management system in the community. Waste bank is a waste management in public space to store community waste in the form of deposits [10][11].

Margajaya Village is part of the Bekasi City area, West Java, which is directly adjacent to DKI Jakarta. Margajaya Village is a sub-district of South Bekasi which has an area of 14.96 km2 with a population of 210,497 people. Waste handling in Margajaya Village already has a waste bank that manages organic/food and inorganic waste. Inorganic waste is managed at the RW level which is carried out once every 2 weeks and people who donate their waste will get a savings book from the results of the kilograms, while organic waste is managed by utilizing mangosteen (BSF) and the scope is still in the RT and is collected every day by the janitor every day but there are also people who come directly to the garbage bank. Sustainable waste management is very important, in this study waste management with the Sustainability Life Cycle Assessment (LCA[a9]) approach as one of the tools that can be used to calculate and analyze the potential environmental impacts of waste management, especially to determine the potential impact of global warming if waste bank management is implemented within the village, so that it can determine the most environmentally friendly waste management that can be used sustainably. With the Sustainability Life Cycle Assessment (LCA) approach to waste management, it is hoped that it can provide an overview and solution for sustainable waste management by considering aspects of environmental impact and increasing products from waste management.

2. Methods

The research used a cross-sectional study design, with hypothesis testing. Then modeling and simulation were carried out to identify problems in processing household food waste. The calculation of the minimum sample size of the waste bank is 100 households[a10] with purposive sampling technique. To find out the concept in improving environmental quality in the future, the Sustainability Life Cycle Assessment (LCA) model of household food waste processing is used. In achieving the research outcome, it is necessary to process and analyze data such as 1) testing a hypothesis 2) sampling the generation and characteristics of household waste 3) Life cycle Assessment (LCA) based on ISO 14040:2006 4) Determination of waste management scenarios. The calculation of household waste generation refers to SNI 19-3694-1994, which is carried out for eight consecutive days per sample, while the identification of household waste characteristics is based on SNI 19-2454-2002[a11].

1. Scenario setting

The scenario setting of this research is to assess and compare the potential environmental impacts of waste processing before and after the implementation of the Waste Bank.

2. Life cycle assessment (LCA) based on ISO 14040:2006

LCA calculations are carried out with GaBi software using inventory data obtained from observations and calculations. This LCA calculation must have data on the estimated amount of waste generation kg/day/KK and the estimated total waste generation tons/day in the Waste Bank. The composition of waste consists of two types, namely unsaleable waste or STJ and saleable waste or SLJ. Saleable waste includes plastic bags, plastic cups and bottles, plastic buckets, paper, cardboard, books, slippers, cans, iron, rubber and used fabrics. Non-saleable waste includes food waste, kitchen waste and yard waste.

3. Data Interpretation

Data that has been collected both univariate and bivariate will be interpreted according to the results of the study. Data presentation can be in the form of tables, garfish or bar charts and others.

4. Conclusions and policy recommendations

The results of the study are expected to provide policy recommendations that are useful and can manage sustainable household waste.

Data analysis was conducted univariately and bivariately. Univariate analysis was used to describe the characteristics of respondents[a12] and the characteristics of household waste types[a13], while bivariate analysis was used to analyze the relationship between household waste generation and community economic strata using the Chi square test with a p-value of 0.05.

3. Results

Table 1. Relationship between economic strata and household food waste generation

Economic strata	Food waste generation				Total		*p-value*	PR (CI 95%)
	A lot		A little					
	N	%	N	%	N	%		
High	6	16.2	31	83.8	37	100%	0.641	0,730 (0.307-1.735)
Middle	14	22.2	49	77.8	63	100%		

Table 1 shows that high economic strata with the highest proportion of food waste generation is 54.7[a14]% (75 people). Meanwhile, the number of drug items[a15] <3 items with inappropriate waiting time for pharmaceutical services was 45.3% (62 patients). Based on the results of statistical tests, the p-value = 0.730 with α = 0.05 was obtained. The p-value> α, so it can be concluded that there is no significant relationship between economic strata and household food waste management. From the analysis, the value of PR = 0.730 or 1.366 was obtained. This shows that people who have a middle economic strata are 1.366 times more likely to generate a lot of food waste compared to people who have a high economic strata.

In this study, the potential environmental impact uses units of kg eq. Based on the analysis of potential environmental impacts in the scenario of processing organic waste with the Black Slodier Fly (BSF) method, it produces the potential impacts of global warming, eutrophication, acidification and ozone depleting.

Table 2. Potential impacts of organic waste treatment scenarios with the Black Slodier Fly (BSF) method

Scenario	Global warming	Acidification	Eutrification	Ozone depleting
Pengolahan sampah organik dengan metode *Black Slodier Fly* (BSF)	0.281 kg CO2 eq	2.37e-3 kg SO2 eq	6.43e-4kg N eq	7.65e-12 kg CFC 11 eq

The management of organic waste with the Black Slodier Fly (BSF) method produces a global warming impact of 0.281 kg CO2 eq, acidification of 2.37e-3 kg SO2 eq, eutrophication of 6.43e-4kg N eq and ozone layer depletion of 7.65e-12 kg CFC 11 eq. The biggest potential impact is the depletion of the ozone layer which is the result of the decay of waste which will form methane gas (CH4).

4. Discussion

Most urban areas in Indonesia have not sorted their solid waste according to waste composition. Only a few households in urban areas segregate waste, even if they do, it is usually because there is a waste

bank that can be used as a place to exchange segregated waste such as bottles, glass, paper, organic and others. Based on the results of the study, it shows that people with middle economic strata produce more food waste than people with high economic strata. This reflects that differences in consumption patterns, culture[a16] and education affect the amount of household waste generated [12][13]. According to Pariathamby (2014)[14] the responsibility of household waste management is the responsibility of wives at 54%, husbands at 23%, adult women at 20% and the rest stated that it is the responsibility of adult men. The containerization pattern in this area is individual and communal containerization. Where all communities do individual disposal first as temporary disposal in a special container and then disposed of in communal disposal. However, some are also transported by waste bank officers to be collected in the waste bank which later if there is saleable waste, it will be sold and organic waste is processed as maggot feed.

The condition of the temporary landfill in the neighborhood is carried out by the local Cleanliness Department for no more than 3 days. This is because the landfill is not too big so it cannot accommodate too much waste for a long time. Neighboring communities that have the availability of facilities are good because they already have adequate facilities and waste storage is no more than 3 days. This is due to the attitude or awareness of the community to have good facilities as well as economic factors playing a role in the availability of facilities, because facilities require spending both for trash containers and the cost of paying monthly garbage that is transported by officers every day. With this problem, the policy suggestions that can be given to waste banks are as follows:

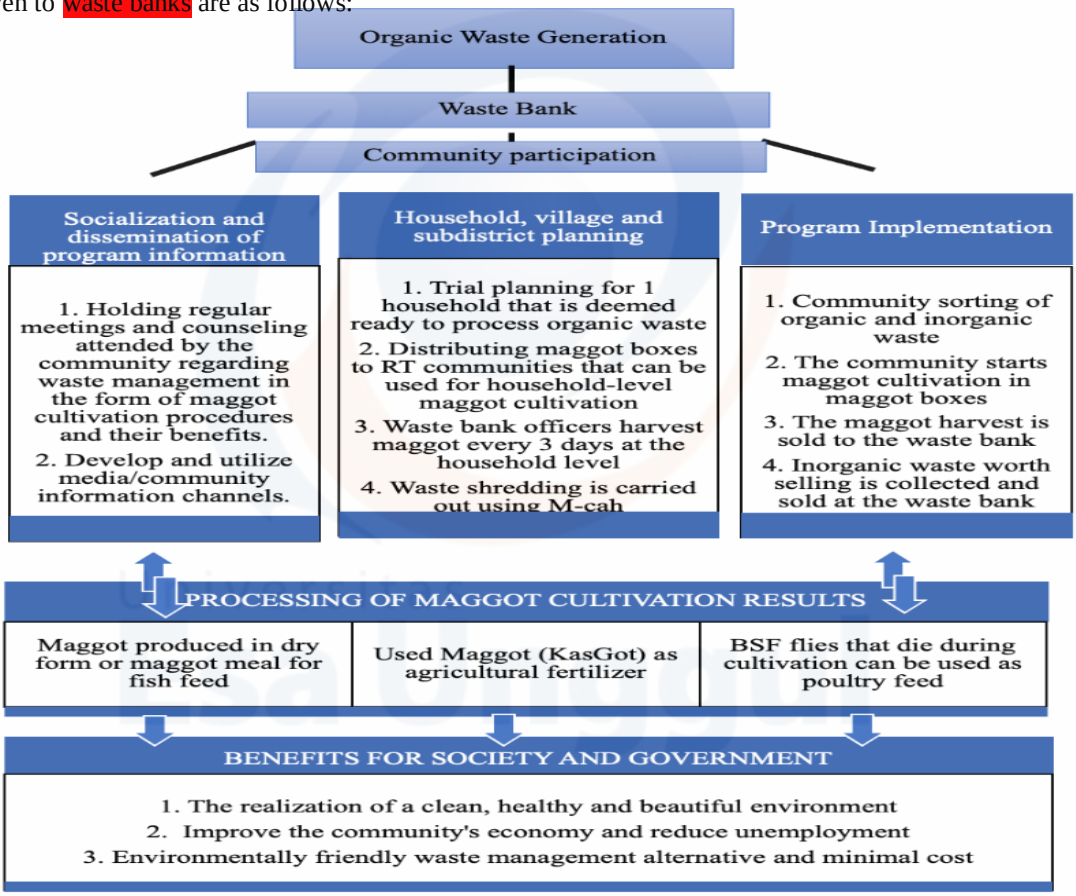

Figure 1: Organic and inorganic waste treatment policy

The management of organic waste with the Black Slodier Fly (BSF) method produces impacts on global warming, acidification, eutrophication and ozone layer depletion. Of the four impacts that produce the smallest impact is the impact of global warming of 0.281 kg CO2 eq compared to other impacts. With the processing of organic waste with maggot (BSF) can reduce the impact on the environment. According to Anasstasia's research (2020) with life cycle assessment (LCA) with the scenario of open landfilling waste processing and open waste burning can produce a greater impact on global warming than waste processing in waste banks, where open dumping waste processing is 13,057 kg CO2 eq and open waste burning is 10,850 kg CO2 eq [15]. Other research shows that open dumping is the highest form of waste management that has the potential to cause global warming impacts due to the absence of gas handling from the waste decomposition process and leachate processing [16][17]. The gas produced from the decomposition of waste will pollute the air, while the leachate produced will pollute the soil and groundwater.

Based on the scenario of processing organic waste with the Black Slodier Fly (BSF) method, the biggest impact still felt to the environment is the depletion of the ozone layer by 7.65e-12 kg CFC 11 eq. Depletion of the ozone layer can be caused by an increase in CFC and CO2 gases which can cause ozone bonds to break loose and thin out and can cause the greenhouse effect and an increase in UV-B radiation which has an impact on the vulnerability of resistance in humans, animals and plants. Where if organic waste is not processed, the impact on the environment will be even greater. Food waste is an inevitable part (34-53%) of total household waste [18]. It is estimated that more than 30% of food produced is wasted globally [19], which is ~1.6 billion tons per year [20]. Therefore, there is a need for efforts to process organic waste, especially food waste in a sustainable manner. Every 1 kg of waste managed by a waste bank can produce a lower potential environmental impact compared to waste that is not processed.

5. Conclusion

The calculation of potential environmental impacts on waste banks by processing organic waste with the Black Slodier Fly (BSF) method can reduce the impact of global warming when compared to the findings of the open dumping environmental assessment which has the highest potential impact in the impact categories of global warming, ozone depletion and others. It was also found that the middle-income community generated more food waste than the high-income community. It can be seen that there are not only economic factors that influence waste generation but also various other factors such as consumption[a17] patterns, education and attitudes.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Commitee of Universitas Esa Unggul (Code : 0923-02.072/DPKE-KEP/FINAL-EA/UEU/II/2023)

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Author's contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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