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Waste Management Strategy of the Free Nutritious Meal Program (*Makan Bergizi Gratis*, MBG) to Realize SDGs 12 Responsible Consumption and Production: A Case Study of Sleman Regency

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ABSTRACT

Sleman Regency has successfully reduced municipal waste generation from 650 g/capita/day in 2019 to 496.27 g/capita/day in 2025, a 23.65% reduction that places it slightly below the average waste generation rate for middle-income countries (500–700 g/capita/day). However, the implementation of the Free Nutritious Meal Program (Makan Bergizi Gratis, MBG) is expected to create new environmental challenges through increased organic waste generation. This study aims to assess the projected waste generation from MBG and formulate a sustainable waste management strategy for Sleman Regency. The research employed a literature review, regional waste data analysis, quantitative estimation of waste generated per meal portion, and scenario analysis using Business-as-Usual and circular economy interventions. The findings indicate that 66 Nutrition Fulfillment Service Units (Satuan Pelayanan Pemenuhan Gizi, SPPGs) serving 251,356 beneficiaries are projected to generate approximately 21.95 tons of organic waste per day, or 5,707 tons annually, representing about 2.67% of Sleman's total annual waste generation. This additional waste may increase environmental pressure, pest and disease vectors, and methane emissions if disposed of without proper segregation. Therefore, source reduction, waste segregation, composting, biodigesters, and maggot cultivation, supported by strong multi-stakeholder collaboration, are essential to promote a circular economy, support Sleman's low-carbon development, and contribute to SDG 12 (Responsible Consumption and Production).

INTRODUCTION

The Free Nutritious Meal Program (*Makan Bergizi Gratis*, MBG) is a national priority policy designed to improve students' nutritional status by providing nutritious food in large numbers and in a sustainable manner. As of January 2026, this program has reached approximately 58.1 million beneficiaries across Indonesia, with distributions every day except holidays, totaling approximately 260 days per year (BGN, 2026).

This large-scale implementation not only has implications for food distribution and logistics governance but also poses significant environmental consequences, particularly related to food waste generation (Food Waste) (Afrianti et al., 2025). If it is assumed that food waste ranges from 50–100 grams per student per day, then nationally the potential for waste generation can reach 2,900–5,800 tons per day or the equivalent of 871,500–1,743,000 tons per year (Javier, 2025). This figure shows that MBG has the potential to become a major contributor to new organic waste in the national waste system.

The problem becomes more complex when most of the organic waste has not been managed separately and is still dependent on the Final Processing Site (*Tempat Pemrosesan Akhir*, TPA). In many areas, the landfill management system still uses controlled landfills or even open dumping, which is at high risk of producing methane (CH_4) emissions from anaerobic decomposition (Setiawan et al., 2025). Methane has a global warming potential 28 times that of carbon dioxide (CO_2) (Edjabou & Scheutz, 2023).

Empirical studies show that every 1,000 tons of food waste can produce about 34 tons of CH_4 per year (Krause et al., 2023). If calculated with a national generation potential of 754,000-1,508,000 tons per year, the methane emissions produced can reach more than 25,636-51,272 tons of CH_4 per year. The large potential for emissions indicates that food waste from the implementation of the MBG program is not only a waste issue but also contributes to increased greenhouse gas emissions, and therefore needs to be integrated into climate change mitigation strategies at the national and regional levels (Pambudi & Fardiani, 2026).

In the regional context, Sleman Regency in the Special Region of Yogyakarta has characteristics that warrant further study. Sleman is an area with a high concentration of high schools and a very large student population. Based on data from *Satu Data Pendidikan Kabupaten Sleman* (2026), the region has 1,912 schools, including 1,146 PAUD, 561 elementary schools, 173 junior high schools, and 32 PKBM, with a total of 192,573 students. In addition, for the SMA/MA/SMK level in Sleman Regency, there are 180 schools, bringing the total number of schools in Sleman to 2,092. This many schools that have received MBG benefits certainly have the potential to generate a large amount of food waste.

On the other hand, research by Pambudi (2025) states that Sleman Regency is still facing challenges in waste management, especially since the operational restrictions at the Piyungan Landfill in 2024 have led to a buildup and an increase in illegal disposal. Reflecting on these conditions, the additional organic waste from the MBG program certainly has the potential to increase pressure on the regional waste system if not managed systematically.

Although various studies have discussed the potential of food waste nationally and the environmental impact of the food sector, studies that specifically estimate the generation of food waste from the implementation of the MBG program at the regional level are still very limited, if not yet found. Previous research has generally focused on nutritional aspects, the effectiveness of program distribution, or program institutions, and thus has not been able to describe variation in waste generation in the local context, influenced by the number of beneficiaries, regional characteristics, and the capacity of the waste management system.

Based on these conditions, this study offers a novel estimate of the MBG program's waste generation at the district scale, illustrating the potential burden of organic waste. Therefore, this study aims to estimate the MBG program's waste generation in Sleman Regency to inform the development of more effective food waste management policy recommendations.

RESEARCH METHODS

Study Design

This study employed a systematic literature review, examining scientific sources to inform the development of a contextual food waste management strategy for the MBG program in Sleman Regency. Sleman Regency was chosen because it has one of the highest school densities in Indonesia and ranks highest in the national Human Development Index (HDI), providing an overview of ideal conditions for waste management. The data sources analyzed included articles from nationally and internationally reputable journals, government policy reports, and regional waste statistics.

Data Collection

Articles were obtained from Web of Science, Scopus, and Google Scholar database sources with search strategies using keywords, including: (1) school feeding, (2) free nutritious meals program, (3) plate waste, (4) food waste, (5) food waste, (6) free nutritious meal program, and (7) organic waste management. The criteria for article selection are: (1) documents in the form of articles, (2) the language used in the article is Indonesian and/or English, (3) food waste, and (4) waste management. The number of articles obtained and subsequently analyzed from the selection process was 19 documents. The review process was carried out in stages: identification, selection, quality evaluation, and thematic synthesis to obtain a comprehensive picture of food waste generation, potential greenhouse gas

Jurnal Pro-life, 13 (2): 298-314, Juli 2026

emissions, and circular economy-based management models, such as composting, biodigesters, and BSF maggot cultivation.

Data Analysis

Technically, the estimated food generation for the MBG program is calculated using a projection approach based on per capita waste generation. Data on the population of Sleman Regency for the 2019-2025 period were obtained from the Central Statistics Agency (*Badan Pusat Statistik*, BPS) of Sleman Regency, while annual waste generation data were obtained from the National Waste Management Information System (*Sistem Informasi Pengelolaan Sampah Nasional,* SIPSN) of the Ministry of Environment and Forestry in 2026, which was specifically used as data for Sleman Regency.

Furthermore, the number of MBG beneficiaries was obtained from the Sleman Regency Education Data Unit in 2026, while the assumption of the program's implementation for 260 days per year is based on *Badan Gizi Nasional* (BGN) data from 2026. The calculation is carried out in several stages as follows. First, calculate the per capita annual waste generation using equation (1).

$$\mathrm{TSK} = \frac{\mathrm{TS}}{\mathrm{JP}}$$

Description:

TSK = waste generation per capita (kg/capita/year)

TS = total waste generation in Sleman Regency (kg/year)

JP = total population (population)

Second, the value of waste generation per capita per year is converted to per-day generation using equation (2).

$$\mathrm{TSD} = \frac{\mathrm{TSK}}{365}$$

Description:

TSD = waste generation per capita per day (kg/capita/day)

TSK = waste generation per capita (kg/capita/year)

365 = number of days in a year

Third, it is assumed that each individual eats three meals per day, so that the waste generation per meal is calculated using equation (3).

$$\mathrm{TSM} = \frac{\mathrm{TSD}}{3}$$

Description:

TSM = estimated waste generation per capita per meal (kg/capita/meal)

TSD = waste generation per capita per day (kg/capita/day)

3 = the number of meals in a day

Fourth, the estimated food waste generation of the MBG program is calculated using equation (4).

$$\mathrm{TL_{MBG}} = \mathrm{TSM} \times \mathrm{P} \times 260$$

Description:

$\mathrm{TL_{MBG}}$ = estimated generation of MBG food waste (kg/year)

TSM = estimated waste generation per capita per meal (kg/capita/meal)

P = number of beneficiaries of the MBG program (souls)

260 = number of days of implementation of the MBG program in one year

This approach is used on the assumption that the generation of food waste at each meal has a relatively equal portion of the total household waste generation per capita, so it can be used as an initial approach (baseline estimation) to describe the potential for food waste generation of the MBG program at the district level.

The results of the quantitative estimation are then interpreted descriptively and critically by emphasizing the relevance of the findings to the social, spatial, and institutional characteristics of Sleman Regency. The literature synthesis is used to formulate food waste management strategies that are applicable, low-emission, and aligned with regional and national low-carbon development targets for implementing the MBG program.

RESULTS AND DISCUSSION

In this sub-chapter, results and discussions are presented, including waste dynamics and profiles, the implementation of the MBG program, estimates of waste generation and its impact, and appropriate management strategies.

Waste Dynamics

Sleman Regency is one of the areas with high population growth dynamics and educational activities in the Special Region of Yogyakarta. The BPS Kabupaten Sleman (2025) reports that in 2024, the population in this region will reach 1,125,571, with a population growth rate of 0.01%. The population of Sleman Regency is quite high, with a population density of 19,591 people/km^{2,} supported by a high human development index (HDI) of 85.71 in 2024, an increase of 0.85 points from 2023. At the same time, this makes Sleman the district with the highest HDI in Indonesia.

Even though Sleman has the highest HDI, it still faces unresolved development problems. One of the most critical issues is waste. So far, Sleman is still relying on the Yogyakarta Provincial Government for waste management. The Piyungan Landfill, which has an area of 12.5 ha, accommodates waste from Yogyakarta City, Sleman Regency, and Bantul Regency, but since 2012, its capacity has exceeded its capacity.

This condition is contrary to the findings of Kim & Go (2020), which report a positive and significant per capita HDI correlation with environmental awareness, including waste management. The availability of waste management infrastructure and facilities allegedly influences this difference. As explained in the study by Pambudi (2025), Yogyakarta, including Sleman Regency, continues to face institutional governance problems in waste management. Many households have been sorted at the source (at home), but the cleaners still mix them into 1 truck during pickup.

This is very different from the infrastructure and institutions in 72 countries studied by Kim & Go (2020); in various developed countries, cleaners have proper vehicles with a capacity of 3 cubic meters, depending on the type of waste (organic, inorganic, and hazardous and toxic waste /

B3). The availability of vehicles with such specifications is very helpful for people who already know how to sort waste at home. At the same time, ensuring that the waste remains sorted until the landfill, there is no potential for remixing, as is still happening in Sleman and DIY.

Waste Profile

Sleman Regency has a population of more than 1 million people and a fairly high rate of waste generation. In recent years, waste remains a serious problem in this region. In detail, Table 1 shows the waste profile of Sleman Regency for 2019-2025.

Quantitatively, Sleman's population increased from 1,075,575 in 2019 to 1,179,382 in 2025, a 9.65% increase. However, per capita waste generation shows a downward trend, from 650 grams/person/day in 2019 to 496.27 grams/person/day in 2025, a decrease of 23.65%. This pattern indicates a relative improvement in the efficiency of waste generation amid population growth.

According to the report by Kaza et al. (2021), the average waste generation in middle-income countries is in the range of 0.5–0.7 kg/person/day, with an achievement of 0.496 kg/person/day in 2025; Sleman is slightly below the lower limit of the global range. This value reached an important turning point in 2022, with per capita waste generation falling by 19.66% to 520 grams/day from 647.24 grams/day in 2021. This achievement can be attributed to changes in consumption behavior, strengthened waste-reduction programs, and constraints in regional landfill operations.

On the other hand, the achievement of handling and reduction shows quite sharp fluctuations. In 2021, it recorded the largest reduction (44,417.98 tons), but it decreased sharply in 2023–2025. This inconsistency indicates that the 3R system has not been institutionalized in a stable manner. Normatively, the national waste management policy is affirmed by *Peraturan Presiden Republik Indonesia Nomor 97 Tahun 2017 tentang Kebijakan Dan Strategi Nasional Pengelolaan Sampah Rumah Tangga Dan Sampah Jenis Rumah Tangga*, which sets targets of 30% waste reduction and 70% handling by 2025.

Table 1. Sleman Regency waste profile 2019-2025

Year	Population	Generation (tons/day)	Per Capita (grams/day)	Handling (tons)	Reduction (tons)
2019	1,075,575	699.12	650.00	66,645.35	1,610.82
2020	1,125,804	701.95	623.51	85,534.10	27,447.82
2021	1,136,474	735.57	647.24	98,436.85	44,417.98
2022	1,147,562	596.73	520.00	121,176.35	17,970.32
2023	1,157,290	601.79	520.00	20,948.08	289.00
2024	1,125,571	601.79	534.65	48,573.28	1,305.15
2025	1,179,382	585.30	496.27	43,759.83	1,129.49

Source: processed from (Sleman Central Statistics Agency, 2025; 2024; 2023; 2022; 2021; 2020; National Waste Management Information System, 2026)

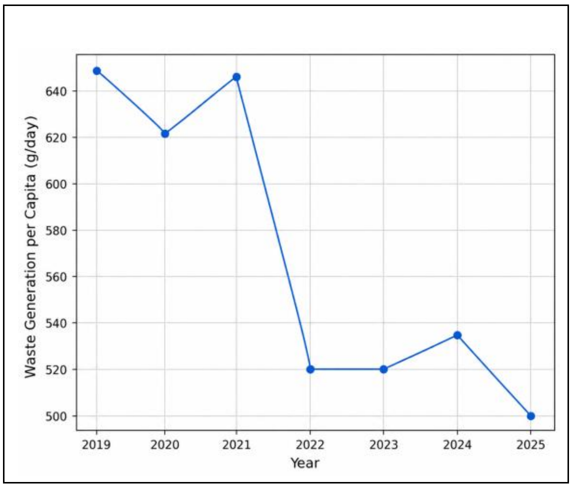

Figure 1. Fluctuations in Waste Generation Per Capita in Sleman Regency (2019-2025)
Source: processed from (Sleman Central Statistics Agency, 2025; 2024; 2023; 2022; 2021; 2020; National Waste Management Information System, 2026)

The fluctuations in Sleman Regency show that, although there has been an increase in handling during certain periods (e.g., 2022), the continuity of the reduction program remains a structural challenge. This is as revealed in the research by Pambudi (2025), that handling waste problems in Yogyakarta, including Sleman Regency, needs to be done by forming a main work team that plays a role in maintaining the sustainability of the waste program, because so far there is still weak coordination and synchronization of the program. Furthermore, Figure 1 shows fluctuations in per capita waste generation, with a pattern of decline but annual dynamics that are not entirely linear.

Figure 1 shows the fluctuations in waste generation per capita in 2019–2025 in Sleman Regency. It can be seen that there was a medium-term decline pattern with anomalous points in 2021, followed by a sharp decline in 2022. Theoretically, the relationship between economic growth, urbanization, and waste generation often follows a curved pattern, the Environmental Kuznets Curve (EKC), where, in certain phases, there is an improvement in environmental performance along with increased awareness and policy intervention. These findings are supported by research by Liang & Yang (2019), which explains that in China, urbanization encourages economic growth, followed by the accumulation of physical, knowledge, and human capital, until environmental awareness is formed and environmental pollution decreases.

In addition, the research by Zhou & Xiong (2025) emphasized that the economic status of communities is positively correlated with awareness of environmental management, including waste sorting at the source. Krause et al. (2023) also underlined that reducing the generation of organic waste at the source is a key strategy for mitigating methane emissions in the waste sector. Sleman Regency, with 496.27 grams/person/day of waste generation in 2025, indicates a positive direction towards waste production efficiency. However, the stability of these trends still requires institutional strengthening, consistency in reduction programs, and the integration of region-based organic management so that the decline is structural and sustainable.

Table 2. Scale of implementation of the Sleman Regency MBG program (As of February 2026)

Components	Quantity	Remarks
Number of SPPG	66 units	Centralized production & distribution kitchen
Elementary and Junior High Schools	1,912 schools	Public and Private, including MI and MTS
High School	180 schools	Public and Private, including MA and SMK
Total beneficiaries	251,356 people	Including PAUD, TK, pregnant and lactating mothers
Operational days/year	260 days	Assumption of effective school days

Table 3. Estimation of organic waste of the MBG program in Sleman Regency

Parameters		Value
Basis for Calculation of Waste Generation	Sleman's total waste generation	496.27 g/capita/day
	Percentage of organic waste	52.80%
	Organic generation per capita/day	262.03 g
	Assumption of 3 meals	87.34 g/capita/serving
Estimated MBG Organic Waste	Organic waste per serving	87.34 g
	Number of beneficiaries	251,356 people
	Total organic waste per day	21.95 tons/day
	Total organic waste per year (260 days)	5,707 tons/year

Implementation of the MBG Program and Waste Generation Potential

Sleman Regency has been implementing the MBG program since the beginning of 2025 and is among the first wave of implementers. The beneficiaries of MBG are not limited to students but also include pregnant and lactating women. Table 2 shows the scale of MBG implementation in Sleman Regency.

Table 2 shows the implementation of MBG in Sleman Regency until September 2025, based on the report by Kusuma & Dennys (2025), which has been supported by 66 Nutrition Fulfillment Service Units (SPPG) spread across various sub-districts. Each SPPG serves as a centralized production kitchen, preparing and distributing thousands of meals daily to beneficiary schools. According to data from the Kabupaten Sleman (2026), there are 1,912 elementary and junior high schools in this area, with a student population of 192,573. Meanwhile, the number of high school equivalent schools is 180 schools. According to the Purnamasari (2026), the number of MBG beneficiaries in Sleman Regency has reached 251,356 people, not only elementary and high school students, but also PAUD, kindergarten, and pregnant women and lactating mothers.

In terms of the number of beneficiaries, the total daily food production is on a very large scale, making MBG one of the largest institutional food supply systems at the district level. The scale of daily food production and distribution through MBG has not only social and health implications but also significant ecological consequences, particularly the potential for organic waste generation. In mass catering systems such as MBG, food waste generally occurs during ingredient preparation, distribution, and residual consumption. Table 3 shows the estimated organic waste of the MBG program in Sleman.

Jurnal Pro-life, 13 (2): 298-314, Juli 2026

Table 4. Comparison of food waste in different countries hosting school feeding

Food Waste Generation	Implementing Countries	References	Remarks
154.22 g/serving	United States	Adjapong et al., 2024	Original research
85 g/serving	Vietnam	Nguyen et al., 2023	Original research
50-100 g/serving	Indonesia	Utami & Malihah, 2025	Estimation
87.34 g/serving	Indonesia	Processed from SIPSN 2026	Estimation
104.2 g/serving	Indonesia	Zuhra et al., 2026	Original research

Table 3 shows that based on the amount of waste generated in Sleman in 2025 of 496.27 grams/capita/day and 52.8% of which is organic waste, the generation of organic waste is 262.03 grams/capita/day. Assuming 3 meals a day, the generation of organic waste is 87.34 grams/capita per meal or per serving. Based on this number, with 251,356 MBG program beneficiaries, the potential for organic waste is around 21.95 tons/day or 5,707 tons/year, assuming 260 grant days per year. This amount is quite large and risks burdening waste management in Sleman Regency. As part of the sensitivity analysis, a comparison of food waste generation was carried out according to Table 4, which presents food waste generated in schools from several countries.

Table 4 shows that the estimated food waste value of 87.34 g/serving used in this study is within the range reported by various studies and institutions, so it can be considered reasonably adequate as the basis for projection. This value is nearly the same as the results of Nguyen et al.'s (2023) research in Vietnam, at 85 g/portion, and is within the range of Indonesia's national estimate proposed by Utami & Malihah (2025), which is 50-100 g/serving.

On the other hand, the results of this study are lower than the findings of Adjapong et al. (2024) in the United States, at 154.22 g/portion, and the research of Zuhra et al. (2026) in South Aceh, Indonesia, at 104.2 g/serving. These variations show that the amount of food waste generated in the school feeding program or MBG in the Indonesian context is greatly influenced by factors such as menu type, portion size, beneficiaries' food acceptance, beneficiary characteristics, and the serving system.

Thus, the estimated results of this study can be categorized as a moderate scenario and show that despite the variation in the assumption of waste generation in various countries or the results of the research, the potential for organic waste from the implementation of the MBG program in Sleman Regency remains at a significant level, so it requires attention in the management system. The implications of the large potential of waste become even more important when considered alongside the waste management capacity of Sleman Regency and the potential environmental impacts that can result if food waste is not managed adequately.

The additional 21.95 tons/day of organic waste is significant, given the trend of declining per-capita waste generation in Sleman Regency. If all MBG waste enters the public waste system without special sorting and processing, this burden could increase the amount of organic waste sent to landfills and disrupt the positive trend achieved over the last four years. According to research by Edjabou & Scheutz (2023), food waste in anaerobic landfills is a major source of methane (CH_4) emissions, with values ranging from 8.0 ± 0.1 to 42.5 ± 1.5 kg CH_4 h^{-1}.

Other research by Citrasari et al. (2025) found that the Piyungan Landfill emits 16,547.04 Mg of methane per year. Based on the report by Krause et al. (2023), methane has a global warming potential 28 times that of CO_2 and a lifetime of 100 years in the atmosphere. Thus, without systematic intervention, the implementation of MBG has the potential to increase pressure on emissions, as dirty as waste, in Sleman Regency.

Furthermore, the problem of MBG food waste is not only a technical transportation issue but also concerns the efficiency of menu planning, portion management, and changes in consumption behavior. The concept of sustainable consumption, as proposed by Guimarães et al. (2024), emphasizes the importance of aligning food policy design with food waste reduction within the sustainable development agenda. Research by Abrillian et al. (2023) reports that organic waste from food scraps and fish bones can support the growth of Black Soldier Fly (BSF) maggot larvae in 12 days, with an organic waste reduction index of 20.72 g/day.

In Sleman Regency, 66 SPPGs currently serve 251,356 beneficiaries under the MBG program. Given the scale of implementation, integrated organic waste management through source segregation, decentralized composting, biodigesters, and Black Soldier Fly (BSF) maggot bioconversion is essential. Such measures would support low-carbon development while preventing unintended environmental externalities associated with increased organic waste generation.

Potential Environmental Impact of MBG Waste Generation

Although designed to increase schoolchildren's nutritional intake nationwide, the MBG program still has the potential to generate substantial waste. The generation of waste has the potential for significant environmental impacts if not managed properly. MBG waste consists mainly of organic food waste, kitchen wastewater, and single-use packaging. If disposed of in the environment without treatment, it can cause water pollution, greenhouse gas emissions, and disturbances to local ecosystems.

According to research by Nemecek et al. (2016), food waste tends to degrade quickly, which can increase the pollutant load on surface and soil waters and produce methane, a greenhouse gas with very high emission potential, if it is anaerobically decomposed in landfills or water bodies without adequate aeration. A systematic approach based on environmental standards such as ISO 14001 is needed to identify, control, and mitigate such environmental impacts in a planned and sustainable manner. Various potential environmental impacts of MBG waste are shown in Table 5.

Furthermore, improper management of single-use plastic packaging may lead to soil pollution and microplastic contamination (Phowan et al., 2026). Thus, indicators such as CH_4, CO_2, BOD, COD, amount of plastics, and microplastics become relevant quantitative parameters for measuring environmental stress levels.

On the other hand, wastewater washing equipment, such as ompreng, broadens the range of impacts on water media. Wastewater with uncontrolled detergent, TSS, and pH levels can trigger eutrophication of water bodies, as described by Akinnawo (2023), who reported that domestic waste contributes 68% to the degradation of river quality.

The findings were emphasized by Wirawan (2019), who conducted research in DKI Jakarta, which found that household domestic waste contributes the largest share to water pollution, at 75%, while office and commercial area wastewater accounts for 15%; the remaining 10% comes from industrial wastewater. Meanwhile, decay in temporary shelters has the potential to create odors and attract disease vectors, according to the findings of Lebreton et al. (2026) regarding the relationship between organic waste and environmental health risks, where bacteria *Escherichia coli* can reach 91.3%, *Klebsiella pneumoniae* can reach 44%, and *Acinetobacter baumannii* and *Pseudomonas aeruginosa* can reach 16.7%.

Table 5. Matrix of potential environmental impact of MBG waste generation

Impact Categories	Source of Generation	Potential Environmental Impact	Impact Parameters
Organic Waste (food waste, vegetables, fruits)	The remaining portion of MBG is not eaten	Greenhouse Gas (CH_4, CO_2) Emissions through decay	CH_4, CO_2 in landfill; organic odor.
		Soil and groundwater contamination	BOD, COD, nutrients (N, P) leak into the soil.
Plastic packaging/ disposable wrap	Plastic Vegetable / Side Dish Wrapping	Plastic pollution on soil and surfaces	Amount of plastic, microplastics
Waste water washing equipment consumption	Dishwashing water, residual soap solution	Eutrophication of water bodies & toxicity	pH, detergent, TSS
Decay in the serving area/temporary shelter	Temporary dump	Smell, vector of pests (flies, rats)	Odor index, pest population

These findings are supported by Saputra et al. (2023), who reported a significant association ($P < 0.05$) between poor waste management and increased diarrhea. Theoretically, Table 2 is relevant to the lifecycle-based environmental management approach (Life Cycle Perspective), which views each stage from consumption, packaging, distribution, to disposal as one integrated system that produces a cumulative impact on soil, water, and air quality. Therefore, proper management can help realize the 12th Sustainable Development Goal (SDG) of responsible consumption and production.

MBG Waste Management Strategy

The implementation of the MBG program in Sleman Regency, which has reached 251,356 beneficiaries through 66 SPPGs (as of September 2025), has direct implications for increasing the generation of daily organic waste. Based on the derivative calculation in Table 3, it is assumed that the average waste is 87.34 grams per serving; the potential generation of MBG food waste can reach ±21.95 tons per day. Without a systematic management strategy, this additional burden risks disrupting the downward trend of regional waste generation and increasing methane emissions from the waste sector. Therefore, the MBG waste management strategy must be designed on upstream-downstream principles, integrating food waste prevention, reuse, and biological treatment. Table 6 shows the strategy for managing MBG waste in Sleman Regency.

Table 6. MBG waste management strategy in Sleman Regency

Actors	Main Role	Form of Action	Success Indicators
SPPG (Nutrition Fulfillment Service Unit)	Reduction of waste at source	Precision portion planning, consumption education, and organic sorting.	Decreased food waste ratio (<10% per serving)
Environment Agency	Regulation & supervision	SOP for sorting, monitoring generation, and facilitation of composters/biodigesters.	≥70% of MBG waste is treated at the source
School/Beneficiary	Behavior change	"Run out of food" campaigns and leftover reporting.	Reduction of residual consumption
BUMDes/Private	Downstream utilization	Compost processing, biogas and maggot cultivation	Compost/biogas and maggot products absorbed by the market
Academics	Mentoring & evaluation	Waste audits, CH_4 emission calculations, and supporting training.	Monthly evaluation reports, science and technology transfers, and policy recommendations.
Local Government	Financing and coordination	APBD/DAK allocation, CSR facilitation, and partnerships with the private sector for the construction of composters or biodigesters	Availability of operational funding and investment in MBG waste treatment

Conceptually, the strategy in Table 6 aligns with a waste management hierarchy that places prevention as a top priority before recycling and final processing. Research by Alexander et al. (2017) emphasizes that about 34% of global food is wasted, so the most effective intervention is control at the consumption and distribution levels. In the context of MBG, age-based adaptive portion management, local preference, and daily leftover monitoring can significantly reduce waste. A school waste management study conducted by Feng et al. (2024) shows that education on eating behavior can reduce food waste by 20–30% in one semester. That is, the technical approach must run in parallel with the social-behavioral approach.

On the downstream side, the utilization of organic waste through composting and biodigesters contributes to the circular economy and emission mitigation. Landells et al. (2025) emphasized in their research on the leadership and institutions of waste management that decentralized organic processing is effective in reducing landfill pressure and methane emissions. For example, processing 21–22 tons of organic waste per day through a biodigester can produce biogas to meet the community kitchen's energy needs. At the same time, the remaining solids are digested into local agricultural fertilizer. On the other hand, research by Arisandy & Fitriani (2024) revealed that treating vegetable waste with 80% biosaka produced an average wet weight of mustard plants of 112-362 g/stem, about 25% greater than without treatment. Thus, the MBG waste management strategy is not only a technical solution for reducing waste but also an instrument for the transition to a low-carbon, climate-resilient food system at the regional level.

Furthermore, integrating MBG waste management strategies has direct implications for achieving SDG 12: Responsible Consumption and Production. Efforts to reduce food inefficiency at the consumption level ensure that food, energy, and resources used in the supply chain are not wasted, thereby increasing the efficiency of production and distribution systems. Adaptive portion management, education on consumption behavior, and source-based sorting reflect responsible consumption practices. At the same time, the processing of organic waste into compost, biogas, and maggot cultivation represents circular, low-emission production. Thus, the upstream-downstream strategy in MBG waste management not only reduces the burden on landfills and methane emissions but also encourages the transformation of regional consumption and production patterns towards a circular economy that measurably and sustainably aligns with SDG12 targets.

CONCLUSION

The Free Nutritious Meal (MBG) Program in Sleman Regency presents two faces of policy: strengthening nutritional security while posing new challenges, namely the potential for significant organic waste generation. On the other hand, Sleman's waste generation in the last five years shows a downward trend. It is even below the global average of middle-income countries, so this achievement is an important capital that must be maintained. However, with 66 SPPGs and 251,356 beneficiaries, the additional daily food waste can amount to tens of tons if not properly managed. Therefore, prevention at the source, changes in consumption behavior, and decentralized organic processing are needed so that MBG strengthens sustainability, especially by reducing regional waste while supporting the achievement of SDG 12, responsible consumption and production. The basic thing that needs to be done by the government is to integrate food waste management into the implementation of the MBG program through source sorting and processing of organic waste at each SPPG (both independently and in partnership with other parties). Given the limitations of this study, which uses secondary data and has not yet been validated by field data, the next study is recommended to directly measure food waste generation across various SPPGs and schools (beneficiaries) to validate the estimation results and inform more targeted policy recommendations.

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