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Estimated Reduction of Greenhouse Gas Emissions from Waste Management in Proklim RW 07, Lesanpuro District, Kedung Kandang District, Malang City

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Abstract

This study was conducted in response to the increasingly critical issue of climate change driven by global warming and the rising concentration of greenhouse gases, particularly methane (CH_4), in the atmosphere. The waste sector is recognized as one of the major contributors to methane emissions, especially through the anaerobic decomposition of organic waste in landfills. To address this issue, the Indonesian Ministry of Environment and Forestry established the Climate Village Program (ProKlim) as a community-based climate change mitigation initiative. However, studies quantifying greenhouse gas emission reductions resulting from waste management activities in ProKlim areas remain limited. Therefore, this research aims to estimate the reduction of greenhouse gas emissions generated through waste management practices in ProKlim RW 07, Lesanpuro Village. Waste volume and composition sampling were conducted using purposive sampling techniques based on SNI 19-3964-1995 guidelines. Greenhouse gas emissions were calculated using the 2006 IPCC Guidelines with the First Order Decay (FOD) Tier 2 method. The results indicate that the total waste generation in RW 07 reached 563.174 kg/day, with a waste generation rate of 0.38 kg/person/day. Following the implementation of ProKlim, 73.7 kg/day of waste was successfully managed, while 489.5 kg/day remained unmanaged. Waste management activities in ProKlim RW 07 contributed to a reduction of methane emissions from landfills by approximately 0.19 tons CH_4/year.

Article Info

Keywords:
Climate Mitigation;
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ProKlim;
Reduction Emissions;
Waste Management;

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1. Introduction

The greenhouse effect refers to the rise in the Earth's surface temperature caused by the heating of the lower atmosphere due to the accumulation of greenhouse gases. This phenomenon results in elevated air temperatures, leading to significant consequences such as global warming and climate change (Mikhaylov et al., 2020). Methane (CH_4) is a substantial contributor to global warming, with a global warming potential 25 times greater than that of carbon dioxide (CO_2) over a 100-year period. The waste sector is the third largest producer of methane gas emissions in Indonesia. CH4 is mostly produced from anaerobic processes such as waste decomposition in landfills. Based on data from the Ministry of Environment and Forestry (2024), it states that in 2023, national greenhouse gas emissions from domestic solid waste (MSW) amounted to 45,244.63 Gg CO2e. The sector with the second largest contribution to GHG emissions in Malang City is the waste sector, at 41% (RPD Malang City, 2023). Based on data from the Malang City GHG inventory report (2021), methane gas emissions from waste generation at the Supit Urang landfill are 756,325 CO2 equivalents. Methane gas emissions will increase if the waste generation also increases. The data series for Malang City waste generation for the last 5 years from 2019-2024 can be seen in Figure 1.

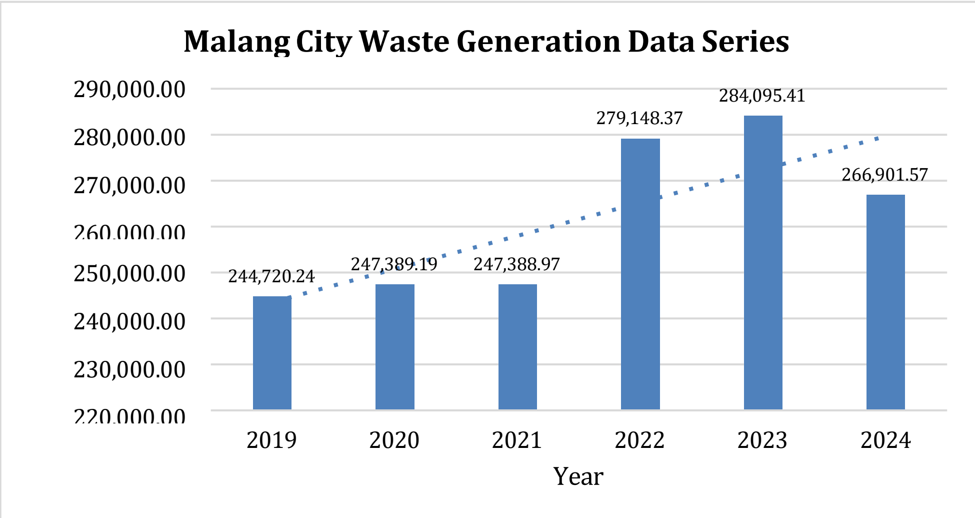


Figure 1. Malang City Waste Generation Data
Series Source: SIPSN, 2025

Based on the graph, Malang city's waste generation tends to increase until 2023 and decreases by 6% in 2024. This decrease in volume can occur due to the seriousness of management carried out by various parties, namely the Government, the Community, Academics, and other parties such as environmental organizations. Management must continue to be improved to achieve Indonesia's target of reducing greenhouse gas emissions by 31.89% independently and up to 43.20% with international support by 2030. One program currently being implemented in Malang is the Climate Village Program (Proklim). This program is mandated by Regulation of the Minister of Environment and Forestry No. 19 of 2012. This program is designed to increase the participation of communities and other stakeholders. The goal is to strengthen adaptive capacity to the impacts of climate change, reduce greenhouse gas emissions, and support local climate adaptation and mitigation efforts that improve community well-being according to local conditions.

One of the areas in Malang City that has implemented the Climate Village Program (Program Kampung Iklim/ProKlim) is Neighborhood Association 07 (RW 07) in Lesanpuro District. The RW 07 community has successfully transformed its area into a leading "Climate Village" at the city level. In 2021, RW 07 received first place in the Kampung Bersinar competition, an environmental management award held throughout Malang City. This achievement reflects the community’s strong environmental management practices, including waste management, water conservation, green open space management, and other environmental initiatives. Most residents of RW 07 have adopted waste management practices based on the 3R principles (Reduce, Reuse, and Recycle) through the implementation of a waste bank program. In addition, communal-scale composting of garden waste has been established, with the resulting compost utilized as fertilizer for plants in community gardens. Recyclable waste is collected and managed by the waste bank, while other materials are reused and transformed into handicrafts or plant pots. Despite these initiatives, accurate data regarding greenhouse gas emission reductions resulting from waste management activities in ProKlim areas remain limited. To date, no specific study in Malang City has estimated greenhouse gas emission reductions in the waste sector resulting from ProKlim implementation. Such analysis is essential to provide a strong empirical basis for designing and implementing effective and sustainable waste management strategies. Furthermore, reliable information regarding emission reductions from neighborhood-scale waste management is needed to support Indonesia’s 2030 greenhouse gas mitigation targets. Therefore, this study aims to estimate the reduction of greenhouse gas emissions in Malang City through waste management practices implemented in ProKlim RW 07, Lesanpuro District.

The findings of this study are expected to provide valuable information for government agencies, local communities, and other stakeholders in efforts to minimize waste generation and reduce greenhouse gas emissions through the Climate Village Program. In addition, this research may serve as a reference for other regions with similar characteristics in implementing mitigation and adaptation strategies related to greenhouse gas emissions.

2. Methods

This study was conducted in the ProKlim area of RW 07 (Neighborhood Association 07), Lesanpuro District, Kedung Kandang Sub-district, Malang City, East Java. Geographically, RW 07 is located at coordinates 7°58'43.2"S 112°39'41.9"E. The location map of RW 07 can be seen in Figure 2.

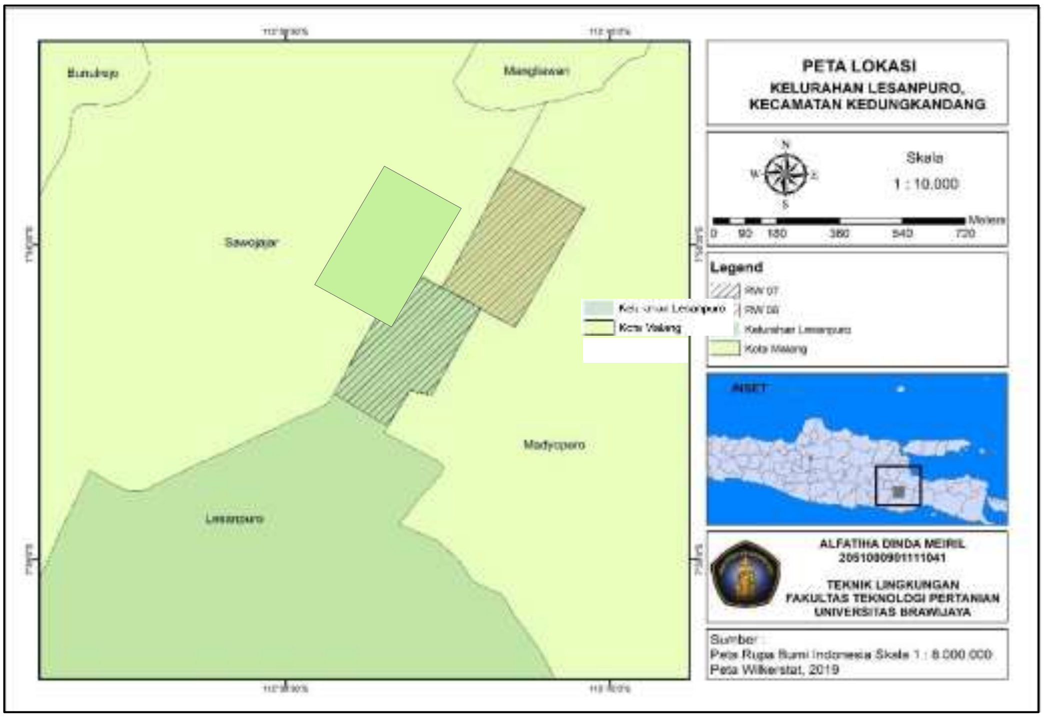


Figure 2. Map of Location RW 07 Lesanpuro Subdistrict
Source: Data processed, 2025

Research Tools and Materials

The tools and materials used in this research included domestic waste as the treatment material, 40-liter plastic bags as containers for collecting domestic waste, a weighing scale to measure the waste weight, latex gloves for hand protection during sampling, a sorting mat as a sorting platform, and Microsoft Excel for processing the research data.

Data Sources

The data utilized in this study consisted of primary and secondary data. Primary data was obtained through direct field measurements and surveys. For this research, the primary data included the rate of waste generation, waste composition, and the existing conditions of waste management at the research site, gathered through interviews with the head of the neighborhood association (Ketua RW) and administrators involved in the Climate Village Program. Secondary data, on the other hand, was obtained from relevant institutions to support the primary data. The secondary data for this study included population figures for Lesanpuro District acquired from the Central Statistics Agency (Badan Pusat Statistik), information regarding the amount of waste received by the waste bank and the number of its customers, as well as the reference data for Greenhouse Gas (GHG) measurement from the IPCC (Intergovernmental Panel on Climate Change) 2006 guidelines.

Research Method

This study employed a quantitative descriptive method. Research utilizing a quantitative descriptive approach uses data in the form of numbers and figures. The results of the calculations are then interpreted to address the predetermined research questions. The research framework is necessary to understand the aspects related to the research. Each stage in the research framework will be described in the research methodology used as a guideline for the implementation of this research. In addition, having a research framework can reduce the risk of errors in the research. The research framework applied in this study can be seen in Figure 3.

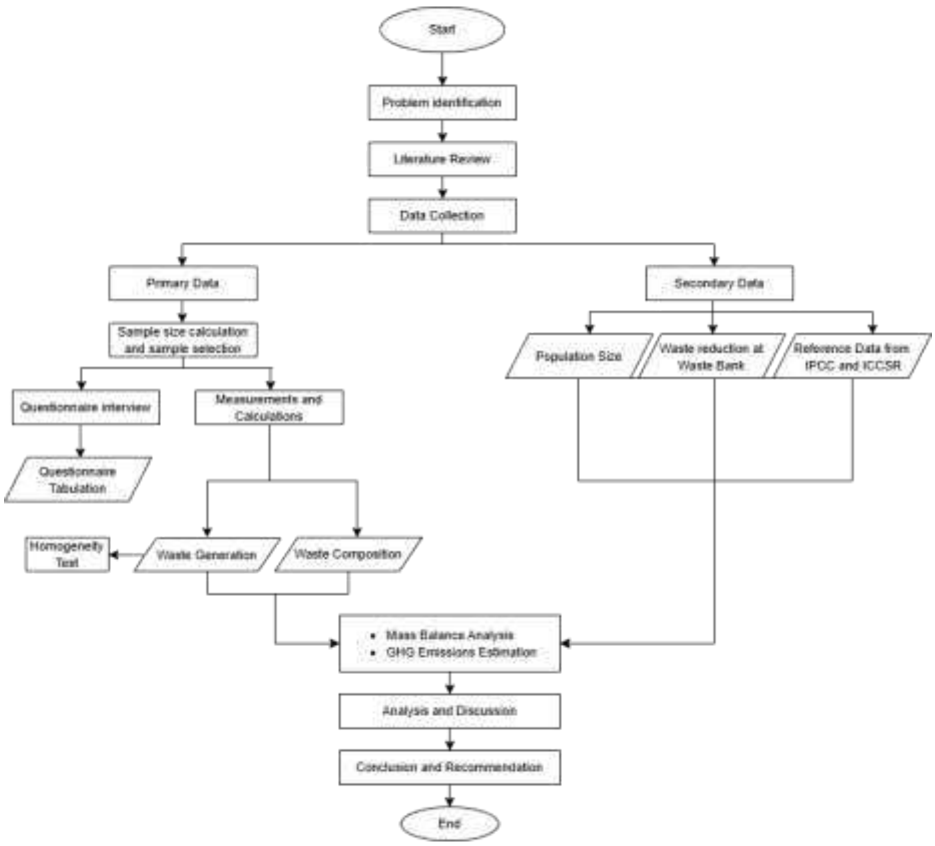


Figure 3. The research framework

Source: Data processed, 2025

Sampling Technique

Determining the number of samples was necessary to accurately represent the waste generation and composition from the research location. The required number of samples was calculated using the equations stipulated in the Indonesian National Standard (SNI) 19-3964-1994 concerning Methods for Sampling and Measurement of Municipal Waste Generation and Composition. According to SNI 19-3964-1994, the number of research samples can be calculated using Equation 1 and Equation 2.

$$S = Cd\sqrt{Ps} \quad (1)$$

$$K = \frac{S}{N} \quad (2)$$

Descriptions :

S	: Number Of Samples (Persons)
Cd	: Housing Coefficient
Cd	: 1 for Large amaetropolitan Cities
Cd	: 0.5 for Medium/Small Cities/Regional Growth Centers
Ps	: Population (Persons)
K	: Number of samples (Households)
N	: Number of persons each Family (assumed to be 3)

The total population of RW 07 consists of 1,459 residents. Based on calculations using Equations 1 and 2, the minimum required sample size was determined to be 13 households. To improve data accuracy and minimize potential errors, the number of sampled households was increased to 30 households. Following the determination of the sample size, households meeting the sampling criteria were selected. The waste generation sampling technique can be seen in Figure 4.

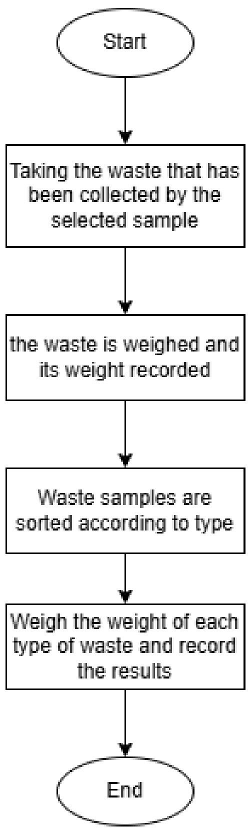


Figure 4. Flowchart of Waste Generation Sampling Technique
Source: Data processed, 2025

Waste generated by residents and disposed of in waste containers was collected and transported to designated field locations for analysis. The collected waste was subsequently weighed and sorted according to waste type. Each waste category was then weighed individually to determine its proportional composition. In this study, waste sampling was conducted using a purposive sampling method at the source. The selected sample households were households not engaged in commercial activities and actively participating in waste management practices.

Sampling permits were obtained in accordance with applicable standards and through coordination with the head of the ProKlim management unit of RW 07. Waste sampling procedures were conducted in accordance with the SNI 19-3964-1994 guidelines. Waste collection activities were carried out for eight consecutive days between 05:00 and 06:00 WIB. Waste from each household was transported to the measurement site, where it was weighed and sorted to determine the mass of each waste component. The waste generation rate was subsequently calculated using Equation 4, while the percentage composition of each waste component was determined using Equation 5.

$$\text{Waste Generation Rate} = \frac{\sum_{i=1}^{n} \frac{Wi}{P}}{n} \qquad (3)$$

$$\sum \text{Waste Generation} = \text{Waste Generation Rate } x \sum \text{Population} \qquad (4)$$

$$\text{Waste Composition} = \frac{\text{Weight of each waste type (kg)}}{Total\ Waste\ Weight}\ x\ 100\% \qquad (5)$$

Descriptions :
Wi : Weight of waste on i-th day
P : Number of sampled population (individuals)
N : Number of sampling days

Homogeneity Test

The homogeneity test is a statistical method used to determine whether two or more sample groups originate from populations with equal variances. The results of this test guide researchers in selecting the appropriate statistical analysis method. By conducting a homogeneity test, researchers can evaluate the quality and consistency of the collected data and identify potential external factors that may influence the results. Homogeneity testing is essential in analysis of variance (ANOVA), as one of the fundamental assumptions of ANOVA is that the variances across groups must be homogeneous. If this assumption is violated, the validity of the ANOVA results may be compromised (Nurwashinda et al., 2025). One commonly used homogeneity test is Levene's Test. Levene's Test assesses the equality of variances among two or more groups by calculating the mean deviation from the median (or mean) for each group and subsequently analyzing the variance of these deviations. If the p-value obtained from Levene's Test is lower than the predetermined significance level, the null hypothesis stating that the group variances are equal is rejected (Aprizan et al., 2025).

Mass Balance

Mass balance is one of the approaches used to analyze both managed and unmanaged waste (Bayazid, 2023). Material balance can be applied to determine the percentage of residual waste and recyclable waste (Artiyani & Dwi, 2019). The data required for this analysis include the total amount of waste generated, the weight of waste by composition, and the weight of waste managed through 3R (Reduce, Reuse, Recycle) activities, composting, eco-enzymes, and others. The percentage of managed waste can be determined using the recovery factor calculation, as presented in Equation (6). Based on these data, the weight of unmanaged waste disposed to the landfill (TPA) can subsequently be obtained.

$$\%Rf = \frac{\text{Weight of managed waste}}{Total\ Weight\ of\ Waste\ by\ Type}\ x\ 100\% \qquad (6)$$

Calculation of Greenhouse Gas Emissions

The calculation of greenhouse gas emissions is based on the 2006 IPCC Guidelines, Tier 2. Tier 2 is selected because actual data or field survey data on specific waste activities are available, while several IPCC default parameters are also used. In this study, the emissions considered are limited to methane gas (CH_4).

$$\text{Emisi } CH_4 = (W \times DOC \times DOCf \times MCf \times F \times \frac{16}{12} - R) \times (1\text{-}OX) \qquad (7)$$

Descriptions :

W : Waste generation (tons/year)

DOC : Degradable organic carbon (fraction) (tons C/ton waste). Calculated as the sum of DOCi x the mass of waste composition that generates methane.

DOCF : Fraction of DOC (0.5, according to IPCC)

MCf : Methane correction factor (value ranges from 0.4 to 1.0, depending on the country's capacity to manage landfill gas)

F : Fraction of CH4 in Landfill (0.5, according to IPCC)

R : CH_4 recovery (tons/year). For cities without a landfill gas recovery system, this is assumed to be 0.

OX : Oxidation factor (0.1, according to IPCC). This factor represents the proportion of CH_4 oxidized by methanotrophic bacteria on the landfill cover surface.

16/12 : Molecular weight ratio of CH_4/C

Global Warming Potential (GWP)

According to Amicarelli et al (2021), each gas possesses a specific Global Warming Potential (GWP), which enables a comparison of the amount of energy absorbed by the emission of one ton of a gas over a given time horizon—typically 100 years—relative to the emission of one ton of CO_2. Carbon dioxide (CO_2) has a very long atmospheric lifetime, such that any increase in its concentration will persist for thousands of years. By contrast, the average atmospheric lifetime of methane (CH_4) is approximately one decade; however, its capacity to absorb energy is significantly greater than that of CO_2. Based on this consideration, methane emissions are commonly converted into CO_2-equivalents (CO_2-eq). This conversion value, referred to as the Global Warming Potential (GWP), reflects the relative radiative forcing of greenhouse gases (GHGs). The GWP values of various GHGs are presented in Table 1.

Tabel 1. *Global Warming Potential*

Greenhouse Gas	GWP (equivalent to CO_2)
Carbon dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous oxide(N_2O)	298
Hydrofluorocarbons (HFCs)	12- 14.800
Perfluorocarbons (PFCs)	7.390 – 12.200
Sulfur hexafluoride (SF_6)	22.800

Source: (KLHK), 2012

3. Results and Discussion

General Overview of the Study Area

RW 07 of Lesanpuro Subdistrict has a total population of 1459 individuals or 472 households, consisting of 9 neighborhood units (RT). RW 07 has been registered as part of the Climate Village Program (Proklim) since 2021. Currently, RW 07 has achieved the top tier Proklim status after receiving an award from the Minister of Environment and Forestry in 2023. The participation of RW 07 is expected to serve as a motivation for other neighborhood units in Lesanpuro Subdistrict to engage in climate change mitigation and adaptation efforts.

Waste Generation

The waste generation of a particular area can be calculated once its waste generation rate is known. The rate of waste generation can be determined using Equation (3). Based on the calculations, the waste generation rate in RW 07 Lesanpuro Subdistrict is 0.386 kg/person/day. With a total of 472 households or 1459 residents, the overall waste generation of RW 07 is 563.174 kg/day.

Homogeneity Test

This analysis employed SPSS version 22 using Levene's Test. The required dataset consisted of waste generation measurements collected over eight consecutive days. When the homogeneity test yields a significance level greater than 0.05, the variances of the corresponding samples are considered not substantially different, indicating that the samples are homogeneous. The hypotheses used in this analysis are as follows.

a. H0 = The data are not homogeneous if Sig (2-tailed) < 0,05
b. H1 = The data are homogeneous if Sig (2-tailed) > 0,005

Table 2. Results of the Homogeneity Test for Waste Generation Variance

Variable	Test Method	Test Statistic	df1	df2	Sig.	Conclusion
Waste Generation	Levene's Test	0.664	7	232	0.702	Humogeneous (p > 0.05)

The homogeneity of variance test was conducted using Levene's Test to verify that the waste generation data exhibited uniform variance across the daily groups. The Levene Statistic value of 0.664 with a significance level of 0.702 (> 0.05) indicates that the data satisfy the assumption of homogeneous variances. Consequently, the analysis can be appropriately continued using a one-way ANOVA to examine differences in mean waste generation across the days.

Table 3. Results of the One-Way ANOVA for Daily Waste Generation

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.	Conclusion
Across Days	2.027	7	0.29	0.272	0.964	No significant difference observed

The ANOVA results indicate an F-value of 0.272 with a significance level of 0.964 (> 0.05), demonstrating that there is no significant difference in the mean daily waste generation across the observation period. This finding suggests that the amount of waste generated remained relatively stable from day to day throughout the measurement period.

Waste Composition

The identification of domestic waste composition in RW 07 was carried out through household waste segregation. Waste segregation was conducted by dividing waste into several categories: organic (kitchen and garden waste), paper, wood, textiles, rubber, plastics, metals, glass, diapers, and residual/other waste. This classification follows the categories of waste that contribute to emissions, as defined by the IPCC (2006). The percentage distribution of household waste composition in RW 07 is presented in Figure 5.

The waste generated in RW 07 is dominated by organic waste, namely food waste at 53.35% and garden waste at 17.71%. Food waste contains a high moisture content, which makes it relatively heavy (Zhang et al., 2023). Kitchen waste has not been comprehensively managed, as the majority of residents still dispose of it in waste containers, despite separating organic and inorganic fractions. The third largest waste category in RW 07 is diapers, accounting for 9.11%. This is due to the fact that most residents are of productive age, and many households still have infants and toddlers who use disposable diapers. In addition to diapers, sanitary pads are also classified within this category. Most women of reproductive age still prefer disposable sanitary pads due to their practicality and availability (Patel et al., 2023).The high usage of diapers and sanitary pads, without adequate waste management or recovery systems, creates environmental problems because these materials require between 250 and 500 years to fully decompose (Prasetyo et al., 2021). The main factors influencing the amount and composition of waste in a given area include population size, socioeconomic conditions, technological advancement, and educational level (Purnomo, 2020).

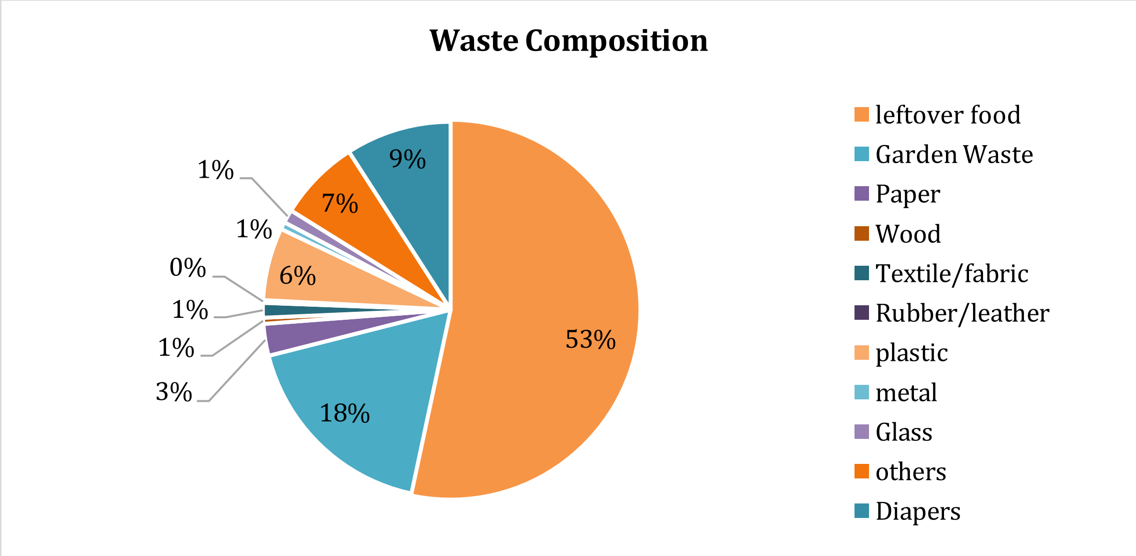


Figure 5. . Waste Composition in RW 07
Source: Processed Data, 2025

Waste Manageent

Proper waste management requires integration across various aspects, starting from upstream to downstream. The upstream aspect includes waste management activities at the initial stage of waste generation, such as at the household level (Al Fariz et al., 2024). Managing waste from the upstream level plays a key role in climate change mitigation, as it helps reduce the burden on final disposal sites (TPA) and minimizes waste accumulation in landfills. In RW 07, ProKlim communities have started implementing the 3R approach (reduce, reuse, recycle), allowing both organic and inorganic waste to be managed more effectively.

A. Organic Waste Management

Organic waste in RW 07 is managed using several methods, including the production of solid fertilizer, liquid fertilizer, eco-enzyme, and animal feed. Composting is one of the most common methods of organic waste processing that can be applied at the household, industrial, or urban scale (Purnomo, 2020). The tools and materials required are also easy to obtain, making it applicable at both individual and communal levels. In RW 07, composting is carried out using the aerobic composter method, which allows harvesting after two months. Aerobic composters are commonly used and are suitable for limited spaces. This composter consists of a perforated plastic drum that enables air circulation (aerobic process). So far, most of the composted material comes from garden waste, while kitchen/food waste is still less frequently processed. This is because many residents are not yet accustomed to or still reluctant to collect their kitchen waste. Several compost bins are available in both communal and individual forms. Unfortunately, compost-based organic waste management has not yet been evenly implemented across all neighborhood units (RTs).

In addition to composting, Eco Enzyme (EE) also serves as an alternative solution for organic waste management in residential areas. EE is a biological method of processing organic waste derived from fruit and vegetable residues, which are mixed with water and palm sugar and then left to ferment for approximately three months. The resulting liquid has a dark brown color and a strong, fresh acidic aroma (Zultaqwa et al., 2023). During the fermentation process, EE produces ozone and oxygen equivalent to that generated by ten trees. Several benefits of EE include river purification, antiseptic properties, soil enrichment, and substitution for daily household chemical products. It can be used as a cleaning and disinfecting solution, such as for mopping floors, cleaning toilets, washing dishes, clothes, windows, and removing grease from stoves or kitchen surfaces (Alkadri and Kristin, 2020). The wide range of benefits provided by EE has motivated RW 07 residents to actively participate in its production, as illustrated in Figure 4. Food leftovers, such as rice, are also utilized by residents as animal feed, particularly for birds, chickens, and fish. This activity is primarily carried out by housewives. Typically, leftover rice is dried before being repurposed as feed. Based on these organic waste management activities, the total volume of organic waste managed in RW 07 amounts to 59.22 kg per day.

B. Inorganic Waste Management

Efforts to manage inorganic waste in RW 07 began with collaboration between the RW administration, Family Welfare Movement (PKK), and the Environmental Agency of Malang City to encourage residents to implement the 3R (Reduce, Reuse, Recycle) program at the household level. This initiative is supported by the provision of two waste bins for each household, placed in front of their homes, to facilitate the separation of organic and inorganic waste. Segregated waste is partially deposited at the community waste bank and partly handed over to waste pickers. Currently, RW 07 operates four communal waste banks, among them are the Waste Bank RW 07, Waste Bank RT 05, Waste Bank RT 07 and Waste Bank RT 08.

Each waste bank in RW 07 operates with a similar collection system, whereby residents can deposit recyclable waste items with economic value. Waste bank staff then sell the collected materials to buyers or collectors once or twice a month. Items with resale value include plastic bottles, paper, cardboard, plastic bags, duplex cartons, glass, iron, and other metals. The revenue generated from these sales is recorded in both the treasurer's ledger and in individual customer savings books. Residents are allowed to withdraw their accumulated savings at the end of the year. Based on data collected from the RW 07 waste bank administrators, the total volume of waste entering the waste banks is 14.489 kg per day. In addition to the 3R program, inorganic waste management in RW 07 is also carried out through upcycling techniques. Upcycling refers to the transformation of inorganic waste into new products without destroying the original material or form (Tjhandra, 2021). Examples of upcycling include converting used plastic bottles into flower pots or garden ornaments, repurposing oil drums into outdoor seating, and reusing old refrigerators as storage containers for used cooking oil, which is later sold to collectors. These creative practices highlight the residents' innovation in establishing a "Kampung Bersinar" (Clean, Healthy, Beautiful, Green, and Neat Village).

Recovery Factor

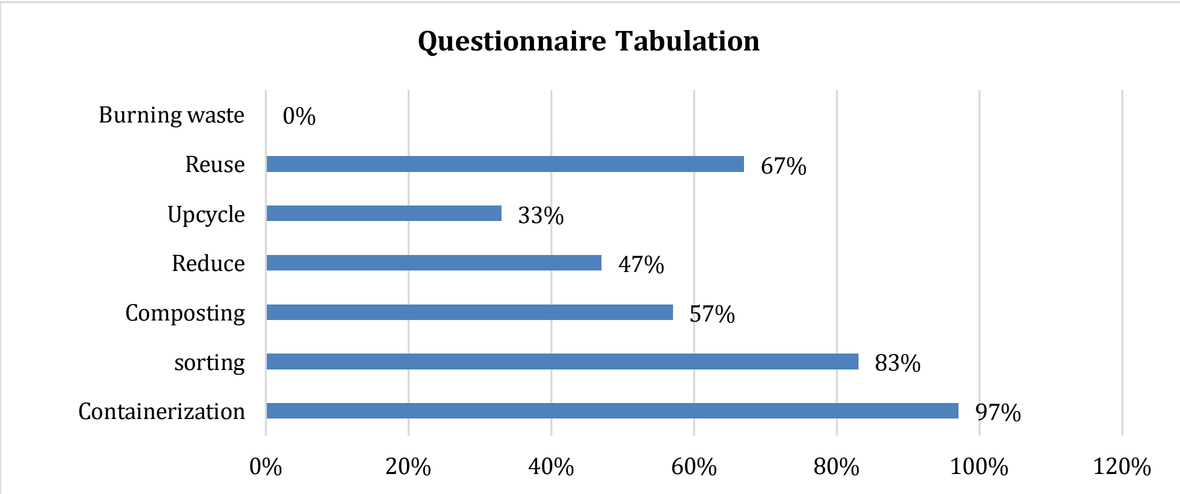
The recovery factor represents the percentage of each waste component that can be reused, recovered, or recycled (Budiharjo et al., 2025). This value is essential in mass balance analysis to determine the extent to which the Climate Village Program (ProKlim) in RW 07 can manage the waste generated. The mass balance analysis requires data on waste generation, waste composition, and the quantity of managed waste, which together allow for the calculation of recovery factors for each waste category. The results of this calculation are presented in Table 4.

Tabel 4. *Recovery Factor*

Type of Waste	RW 07			
	Waste Generation without Management (kg/day)	**Managed Waste (kg/day)**	**Recovery Factor (%)**	**Waste Generation with Management (kg/day)**
	a	b	c	d = a-b
Food Waste	300.5	32.4	10.8%	268.1
Garden	99.7	26.9	26.9%	72.9
Paper	15.4	8.3	53.7%	7.1
Wood	2.9	0.0	0.0%	2.9
Textile/Fabric	7.1	0.0	0.0%	7.1
Rubber	1.3	0.0	0.0%	1.3
Plastic	35.2	4.6	13.0%	30.6
Metal	3.6	0.9	24.3%	2.7
Glass	6.5	0.7	11.6%	5.7
Others	39.7	0.0	0.0%	39.7
Diapers	51.3	0.0	0.0%	51.3
Total	**563.2**	**73.7**		**489.5**

Source: Processed Data, 2025

Based on the calculations presented in Table 2, it can be observed that the proportion of managed organic waste in RW 07 is 10.8% for food waste and 26.9% for garden waste. Among inorganic waste, only paper, plastic, metal, and glass are managed, as collectors generally do not accept waste such as textiles, rubber, and multilayer packaging. The proportion of managed paper waste is 53.7%, followed by 24.3% for metal, 13% for plastic, and 11.6% for glass. Overall, the proportion of managed waste remains relatively low when compared to the national targets set by Presidential Regulation No. 97 of 2017, which aims for a 30% reduction in waste generation and 70% waste handling by 2025. According to data from the RW 07 waste banks, only 10.42% of the total population of 1.459 residents actively deposit waste at the waste banks. This is despite the fact that the majority of households are already accustomed to separating organic and inorganic waste at the household level. Based on in-depth interviews using questionnaires (Figure 8), it was found that 83% of respondents (out of 30 sampled households) stated that 83% of the community have sorted waste at home and 57% have composted. However, the community is still hindered from collecting sorted waste to the waste bank due to busy schedules and the lack of community activity in RW social activities. This situation presents both an opportunity and a challenge for the waste bank management and the RW parties to intensify outreach to the community in order to increase awareness of participation in environmental management. Berdasarkan penelitian Wukandani dan Sembiring (2019) The sustainability of waste management is supported by active community participation in technical operations, financing, and institutional arrangements, as well as by government and private-sector support in providing waste management facilities.



Questionnaire Tabulation
Source: Processed Data, 2025

Greenhouse Gas Emission Reduction

Unmanaged waste from RW 07 is disposed of at the Temporary Disposal Site (TPS) and subsequently becomes residual waste at the landfill (TPA). When organic waste is mixed and buried with other residual waste, it undergoes anaerobic decomposition, which has the potential to generate methane (CH_4) emissions within approximately 13 months. If all waste from RW 07 were to be disposed of directly at the landfill without any prior management, the potential CH_4 emissions are shown in Table 5.

Table 3. Estimation of CH_4 Emissions

Condition	Waste Generation (Ton/Year)	Estimated CH_4 Emissions (Ton CH_4/Year)	Emission Reduction (Ton CH_4/Year)
Estimation of CH_4 Emissions without Waste Management	202.767	1.5112	0.2
Estimation of CH_4 Emissions with Waste Management	176.23	1.3141	

Source: Processed Data, 2025

After the calculations were carried out, it was estimated that CH_4 emissions generated from the waste stream of RW 07 without any waste management amounted to 1.51 tons CH_4/year. Meanwhile, emissions from RW 07 waste after the implementation of waste management were reduced to 1.31 tons CH_4/year The findings of this study indicate that the total emission reduction reached 0.20 tons of CH_4 per year through a combination of waste management practices, including waste banks, composting, eco-enzyme production, and the utilization of leftover rice. The percentage of waste reduction remains relatively low because waste management efforts at the neighborhood (RW) level are still limited in scale, and participation is largely voluntary. Currently, only a portion of the community is actively involved in household waste management practices and in depositing recyclable waste to the waste bank. In addition, there are no binding regulations or mandatory policies requiring all residents to manage household waste at the source or participate in waste bank activities. As a result, the overall effectiveness of waste reduction efforts in the study area has not yet reached its optimal potential. Therefore, comparisons with the literature can only be made in terms of reduction patterns and percentages, rather than total emission magnitudes. According to Suharto et al. (2022), organic waste management at the TPST 3R Mulyoagung Bersatu facility was able to reduce up to 80% of CH_4 emission potential. This relatively high reduction was primarily attributable to the large volume and high efficiency of organic waste processing. Similarly, Prianto and Murti (2024) reported an emission reduction of 11.5% at the Selopuro Village landfill in Ngawi Regency, resulting from waste recovery by scavengers and composting activities. In contrast, the present study shows that only 37.7% of the total organic waste generated was successfully processed, leading to a comparatively lower emission reduction potential. These results suggest that the differences in Although the reduction in methane emissions is still relatively low, there remains substantial potential for improvement since the majority of residents are already accustomed to separating waste. Indonesia has committed to reducing greenhouse gas emissions by 29% through domestic efforts and by 41% with international support by 2030 compared to the business-as-usual (BAU) scenario. The Climate Village Program (ProKlim) represents a concrete community-based action to support this target. According to data from the Ministry of Environment and Forestry (KLHK, 2023), the number of ProKlim locations increased by 128% in 2023 compared to 2022. In 2023, GHG emission reductions from 598 ProKlim sites amounted to 343,534.43 tons CO_2eq, derived from four main sectors: forestry (39,119.83 tons CO_2eq), agriculture (53,358.67 tons CO_2eq), waste management (169,148.3 tons CO_2eq), and energy (81,907.63 tons CO_2eq). For 2024, KLHK has targeted the establishment of 20,000 Climate Villages (DJPPI KLHK, 2023). This target requires strong synergy between the Environmental Agency, local communities, and academia to further enhance the effectiveness and sustainability of the program.

sustainable urban transformation. The framework therefore contributes both theoretically and practically to broader discussions concerning creative cities, Media Arts ecosystems, collaborative governance, and sustainable urban development within emerging economies.

4. Conclusion

Based on the research results, it can be concluded that the total waste generation in RW 07 is 563.174 kg/day, with a per capita generation rate of 0.386 kg/person/day. The largest waste components are food waste and garden waste. Existing waste management practices in RW 07 include the operation of four communal waste banks, composting activities, eco-enzyme production, and upcycling initiatives. Based on the mass balance analysis, the proportion of managed waste in RW 07 after the implementation of ProKlim reached 13%, which remains below the National Waste Management Policy and Strategy (JAKSTRANAS) target of 30% waste reduction. The reduction of CH_4 emissions achieved through waste management activities in ProKlim RW 07 is estimated at 0.2 tons CH_4/year. Currently, only 10% of the total organic waste generated is being processed, despite the significant contribution of organic waste to methane emissions when disposed of in landfills. Although most households in RW 07 already separate organic and inorganic waste at the household level, some residents are still reluctant to deliver recyclable materials to the waste bank.

Therefore, achieving greater greenhouse gas emission reductions at the neighborhood scale requires stronger policy support and broader community participation in waste management activities. Local governments and community leaders should establish more binding regulations and incentive-based mechanisms to encourage household participation in waste segregation and waste bank programs. Incentives may include financial rewards, reductions in waste service fees, or community-based environmental appreciation programs. In addition, regular environmental education and awareness campaigns should be strengthened to improve public understanding of the environmental and economic benefits of waste management. To increase the capacity of organic waste processing, it is also necessary to expand composting and bioconversion facilities, provide technical training for residents, and strengthen institutional support for community-based waste management systems. These efforts are expected to enhance community participation, optimize organic waste treatment, and contribute more significantly to greenhouse gas emission reduction targets within ProKlim areas.

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Conflict Of Interest
The author states that there is no conflict of interest in this study that can affect the process or results of the research.

Data Availability
The data from the research results are available and can be accessed through a request.

Author Contributions
The contributions of the authors in this study are as follows:
- **Conceptualization and research design**: all authors
- **Data collection (observations, interviews, documentation)**: first, second, and fourth authors
- **Data analysis**: first, second, and fourth authors
- **Manuscript drafting**: First author
- **Reviewing and editing the manuscript**: all authors

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