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Regional Case Study

Analysis of Solid Waste Generation, Composition, and Economic Potential Using Cost-Benefit Analysis Method

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Abstract

The Natar market is experiencing an increase in solid waste generation that has not been resolved optimally due to inadequate Temporary Waste Storage Site facilities and a lack of awareness, causing waste accumulation and the transfer of problems to the landfill. This study aimed to analyze solid waste generation and composition based on SNI 19-3964-1994 and to assess the economic potential of recycled waste and the cost-benefit analysis for organic waste processing. The amount of waste produced at the Natar Market was 884.45 kg per day and 7,902.33 liters per day. The composition of solid waste is dominated by organic waste (87.34 %), Low-Density Polyethylene plastic (8.70 %), paper/cardboard (2.14 %), Polyethylene Terephthalate plastic (1.27 %), and other types of waste less than 1%. The selected waste processing alternative was the Black Soldier Fly technology, with a scoring and weighting result of 418 points. Recycled waste has the potential to generate an economic value of IDR 2,151,796.50. The cost-benefit analysis shows that Black Soldier technology is feasible to implement with a Net Present Value of IDR 497,543,239.61, an Internal Rate of Return of 12%, and a Benefit Cost Ratio of 1.017.

Keywords: Natar market; solid waste composition; solid waste economic potential; solid waste generation

1. Introduction

Population growth and increasing economic development have led to an increase in waste production as a result of human activities that generate waste (Addae et al., 2023). Consumer lifestyles have increased the quality and quantity of solid waste. Most waste is disposed of in landfills, where it piles up without further management (Raghu and Rodrigues, 2020). The negative impact of waste piles on the environment includes water and soil pollution due to pollutants entering water and soil surfaces. In humans, it can cause diseases and discomfort (Yin et al., 2024). Mixed waste is difficult to sort and loses its economic value over time. A lack of understanding of proper waste sorting and the unavailability of supporting equipment are factors that influence waste sorting activities. Proper waste sorting practices are important for minimizing environmental pollution and increasing waste recovery (Dutta-Powell et al., 2023).

Commercial areas, such as markets, contributed 45,905.88 tons/year of waste in 2023, with food waste accounting for 39.78%, plastic 19.19%, wood or twigs 12.03%, paper 19.19%, and other materials 18.2% (Ministry of Environment and Forestry, 2023). The increase in market waste has caused waste piles in market environments, which have a negative impact on human health and the environment (Addae et al., 2021) Based on data from interviews, the Natar Market is the largest market center in the Natar District, with an area of 9000 and a population of 198,665 in the Natar District in 2024 (Mulyasa, 2023). A large population will increase the number of market visitors, causing congestion. Market activities that cause congestion increase the amount of waste generated (Ada et al., 2025).

Before and after market revitalization, market management provided a temporary waste storage site (TWS); however, the lack of awareness among traders and visitors in waste disposal caused piles of waste to accumulate around the market area. According to the reference, there is an active waste collection point at Natar Market (Cambodia et al., 2022); however, when the researcher visited the site, it was found that the condition of the waste collection point was inadequate. The inadequate condition of the waste collection point has caused market waste to pile up to the point of nearly blocking the road and producing an unpleasant odor due to leachate generated during rain, thereby disrupting community activities. The piles of waste from market activities only shift the problem from the market to the landfill, which causes new problems for the environment. In the waste disposal process, the Natar Market management collaborated with the Tanjung Sari landfill, which implemented an open dumping system and had not yet implemented sustainable waste management. Improper waste management negatively impacts the environment and human health (Alves et al., 2025).

Waste management efforts are carried out by processing organic waste using alternative technologies. The selection of waste treatment technologies uses Black Soldier Fly, vermicomposting, and windrow composting in accordance with waste treatment technologies that are suitable for application in tropical climates such as Indonesia. Waste generated can be a potential resource for recovering and managing market waste into a product that has economic value in overcoming market environmental problems (Kihila et al., 2021). Although previous research on market waste has been dominated by technical characterization, this study fills a critical gap by integrating a comprehensive Cost-Benefit Analysis (CBA) to evaluate the economic viability of community-based waste recovery. Using Natar Market as a representative model for traditional markets in developing regions, this study provides a scalable economic framework that demonstrates how local waste sorting can be transformed into a profitable and sustainable strategy for waste management. Therefore, this study was conducted to analyze the generation, composition, and economic potential of market waste Using Cost-Benefit Analysis Method. This study aims to provide alternatives for reducing market waste and support the South Lampung Environment Agency in achieving waste reduction targets.

2. Methods

2.1 Study Area

This study was conducted at the Natar Market located in Natar District, South Lampung Regency, Lampung Province, with an area of 9.000 m^2 in 2025. This type of market is a traditional market owned by the government, which has only been revitalized into a modern market concept since 2025. The Pasar Natar area consists of 779 stalls, of which 611 are active, with one trader per stall. Trading activities consist of 11 categories of traders in Pasar Natar.

The selection of the Natar Market as the research location was based on its strategic location on Jalan Raya Lintas Sumatra, which makes it the largest market center in the Natar District with a population of 198,665 people in 2024. Considering the crowded market activities that increase the amount of waste and the location of the market on the edge of the Trans-Sumatra road, the author chose to conduct research here. Through this research, the author hopes to provide solutions and opportunities for addressing sustainable waste management

(A) **(B)**

Figure 1. Research area in Natar Market, South Lampung

2.2 Collection of Solid Waste Generation and Composition Data

Consecutive 8-days solid waste sampling activities using the SNI 19-3964-1994 method. Data collection was conducted over an eight-day period from February 9 to 16, 2025. The sampling equipment and materials consisted of 40 liter black plastic bags, 20 × 20 × 100 cm volume measuring boxes, and personal protective equipment. Waste sample points for each type of trader were measured using the proportional random method, with a calculation result of 28 samples. Random selection was performed in each category, and sample bags containing waste were provided. After the waste samples were collected, weighed, and measured by volume, the waste was sorted to distinguish each component, and weighed and measured individually.

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

$$Ns = \frac{Ni}{N} \times S \quad (2)$$

In Eq. (1) S represents the number of examples of each type of market building, Ts refers to the number of market buildings, and Cd refers to the market building coefficient. The value of Cd = 1. Meanwhile, Eq (2), Ns represents the number of samples by merchant group, Ni refers to the population size by merchant group, N refers to the total population size, and n refers to the population sample size.

2.3 Data Collection Scoring and Weighting

Decision-making techniques are required for selecting waste management technology using scoring and weighting. The scoring method is a qualitative data analysis technique used to assign a value to each criterion from the sub-criteria to calculate the value and determine the ranking (Wulandari, 2023). Technology selection involves technical, environmental, social, and economic criteria. The proposed technology alternatives include black soldier fly, vermicomposting, and windrow composting. The percentage weights were determined from interviews with the South Lampung Environment Agency in the waste management sector. The details of the criteria and sub-criteria sourced from journal literature and books related to the selection of waste treatment technology are presented in Table 1 (Zabaleta et al., 2020).

Table 1. Criteria and sub criteria for selecting organic waste processing technology

No	Criteria	Sub criteria	Unit
1.	Technical	Water requirement	Liters of water/ton of waste (L/ton)
		Energy requirement	kWh of energy/ton of waste (kWh/ton)
No	**Criteria**	**Sub criteria**	**Unit**

No	Criteria	Sub criteria	Unit
		Processing time	Days/ton of waste (days/ton
		Land requirement	m^2/ton of waste (m^2/ton)
2.	Environment	CH_4 emission	Gram/ton of waste (g/ton)
		N_2O emission	Gram/ton of waste (g/ton)
		CO_2 emission	Kg/ton of waste (kg/ton)
		Waste mass reduction	% waste reduction (%)
		Types of vegetable waste	-
		Types of fruit waste	-
		Types of food waste	-
		Types of fish and meat waste	-
		Leachate from waste treatment	-
3.	Economics	Net Present Value (NPV)	NPV/ton of waste (NPV/ton)
		Internal Rate of Return (IRR)	IRR/ton of waste (IRR/ton)
		Benefit Cost Ratio (BCR)	BCR/ton of waste (BCR/ton)
4.	Social	Job creation	Person/ton of waste (Person/ton)
		Public health	-

Each criterion is used as a tool to assess the sustainability of organic waste processing technologies. Each assessment criterion consists of several sub-criteria that consider the potential of organic waste processing technology. The technology and assessment indicators were then selected by identifying the assessment aspects from data collection to the end. The following table presents a basic description of the scoring system

Table 2. Basic description of scoring

Sub criteria	Black Soldier Fly	Windrow Composting	Vermicomposting
Water requirement	200-2200 liters of water/ton of waste (Siddiqui et al., 2022; Zabaleta et al., 2020).	5-100 liters of water/ton of waste (Zabaleta et al., 2020).	5-44 liters of water/ton of waste (Vijayshankar et al., 2024; Zabaleta et al., 2020).
Energy requirement	0.525-105 kWh of energy/ton of waste (Zabaleta et al., 2020).	30-555,556 kWh energy/ton of waste (Pergola et al., 2020; Zabaleta et al., 2020).	30-55 kWh of energy/ton of waste (Zabaleta et al., 2020).
Shredding time	14-45 days/ton of waste (Dortmans et al., 2021; Zabaleta et al., 2020).	30-180 days/ton of waste (Destiasari et al., 2023; Sekarsari et al., 2020).	30-75 days/ton of waste (Zabaleta et al., 2020).
Land requirement	65.03-150 m^2/ton of waste (Bsf et al., 2023; Zabaleta et al., 2020).	180-300 m^2/ton of waste (Zabaleta et al., 2020).	300-580 m^2/ton of waste (Zabaleta et al., 2020).
CH_4 emission	0.4-90 grams/ton of waste (Ermolaev et al., 2019; Mertenat et al., 2019).	1520-2000 grams/ton of waste (Pergola et al., 2020; Zabaleta et al., 2020).	4.8-40 grams/ton of waste (Zabaleta et al., 2020), (Yasmin et al., 2022).
N_2O emissions	8.6-63.3 grams/ton of waste (Zabaleta et al., 2020), (Mertenat et al., 2019).	7.5-200 grams/ton (Mertenat et al., 2019; Pergola et al., 2020).	1.2-10 grams/ton of waste (Yasmin et al., 2022; Zabaleta et al., 2020).

Sub criteria	Black Soldier Fly	Windrow Composting	Vermicomposting
CO_2 emissions	2.3-164.7 kg/ton of waste (Muslih and Bagastyo, 2022; Zabaleta et al., 2020).	108.6-155.97 kg/ton of waste (Muslih and Bagastyo, 2022; Zabaleta et al., 2020).	3.8-167.59 kg/ton of waste (Muslih and Bagastyo, 2022; Zabaleta et al., 2020).
Treatment leachate	Lower leachate from windrows (Ratni and Dewinda, 2022; Safitri Nurkomariyah and Rachmanto, 2023).	Moderately high leachate due to aerobic conditions (Destiasari et al., 2024).	Lower leachate (Sossou et al., 2024).
Waste reduction	50%-93% (Arshad et al., 2023), (Amrul et al., 2022).	35%-40% (Zabaleta et al., 2020).	40%-80% (Zabaleta et al., 2020).
Type of vegetable waste	Appropriate (Ratna Endah Dwi Puspitasari & Murti, 2024).	Suitable (Zabaleta et al., 2020).	Suitable (Zabaleta et al., 2020).
Type of fruit waste	Suitable (Ratna Endah Dwi Puspitasari and Restu Hikmah Ayu Murti, 2024).	Suitable (Zabaleta et al., 2020).	Suitable (Zabaleta et al., 2020).
Type of food waste	Very suitable (Triwandani et al., 2023).	Suitable (Zabaleta et al., 2020).	Suitable (Zabaleta et al., 2020).
Type of fish and meat waste	Suitable (Putra and Ariesmayana 2020).	Suitable (Zabaleta et al., 2020).	Not suitable (Zabaleta et al., 2020).
Net Present Value (NPV)	NPV of Rp1,151,042,824 (Bahtiar and Kamelia, 2023).	NPV of IDR 496,666,866 (Laili, 2017).	NPV of Rp131,134,192 (Hasta Pratopo et al., 2023).
Internal Rate of Return (IRR)	IRR of 59.8% (Bahtiar and Kamelia, 2023).	IRR of 18.55% (Laili, 2017).	IRR of 16.29% (Hasta Pratopo et al., 2023).
Benefit Cost Ration (BCR)	BCR of 4.79 (Bahtiar and Kamelia, 2023).	BCR of 3.45 (Laili, 2017).	BCR of 1.065 (Hasta Pratopo et al., 2023).
Job creation	1-3 people (Bsf et al., 2023; Zabaleta et al., 2020).	1-2 people (Zabaleta et al., 2020).	1-2 people (S. Liberty et al., 2022).
Public health	Generates odors and hazards (Michishita et al., 2023). Pintowantoro et al., 2022; Siddiqui et al., 2022).	Produce biological air bioaerosols (Robertson et al., 2019).	Produce lower air pollution or bioaerosols (Destiasari et al., 2024; Robertson et al., 2019).

2.4 Economic Potential Data Collection

Determining the economic potential of recycled waste using price data from waste collectors. Determination of the economic potential of organic waste using the cost-benefit analysis method with the calculation of net present value, internal rate of return, and benefit-cost ratio. Before the calculation, it is necessary to plan waste processing facilities to determine the facility requirements for reception and pretreatment units, waste processing, and breeding. The economic parameters estimated are from the point of view of the government and society as beneficiaries, investment costs, a 30-year technology period, Bank Indonesia discount rate in 2025, residual value, cost, and benefit components. The investment, operational, and maintenance cost components were sourced from the marketplace in 2025. The direct benefit components are product income and waste service retribution, and the indirect benefit components are secondary data literature.

2.5 Data Analysis

The data analysis method used was descriptive analysis, which included waste generation, composition, and economic potential. This approach was used to calculate waste samples for eight days by presenting waste generation and composition in graphical form. The results of waste generation are expressed in kg/trader/day and l/trader/day using the formula in Equation 3 (National Standardization Agency, 1994). The waste composition formula in Equation 4 is calculated as a percentage of the total waste generated (National Standardization Agency 1994). Waste density is used for the technical planning of waste treatment facilities. Determination of waste density divides the weight (kg) by the volume of waste generated (m^3).

$$Waste\ generation = \frac{Amount\ of\ waste\ (kg/liter)}{Number\ of\ waste\ producing\ units\ (traders)} \tag{3}$$

$$\%\ Waste\ composition = \frac{Waste\ component\ weight}{Total\ weight\ of\ waste}\ x\ 100\% \tag{4}$$

Based on the interview results, the weight value for each subcriterion was determined. The basis of the scoring used is in the range of scores 1-5, determined from the results of the author's analysis, which is explained for each assessment. The scoring and weighting results are calculated using Equation 5. The selected alternative waste treatment technology is obtained from the final results of the highest score and weighting.

$$Final\ result = \sum Weight(\%) \times Score \tag{5}$$

The results of the waste mass balance calculation are presented in the form of a flow chart. The processed material was determined by multiplying the recovery factor percentage by the waste generation of a certain type. Waste residue is calculated using the waste generation formula minus the processed materials. The mass balance results were used for the technical planning of Black Soldier technology facility requirements and economic potential. Subsequently, the cost and benefit components were calculated. The indirect benefit component of reducing emissions CO_2 of waste transportation and emissions CH_4 in landfills used the Minister of Environment Regulation No. 12 of 2010 and IPCC (2006) (Ministry of Environment, 2010), (IPCC, 2006). Equations 6, 7, and 8 were used to calculate the cost-benefit analysis component (Dr. Vladimir, 1967).

$$Net\ Present\ Value = \sum_{t=0}^{n} \frac{Cash\ flow\ for\ the\ year\ to-t}{(1+discount\ rate)^t} \tag{6}$$

$$Total\ Investment = \sum_{i}^{t} \frac{Annual\ profit}{(1+IRR)^t} \tag{7}$$

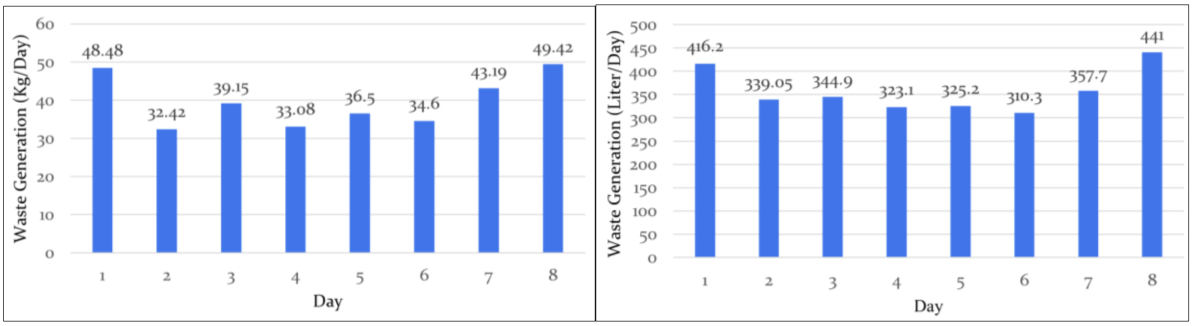
$$Benefit\ Cost\ Ratio = \frac{PW\ of\ Benefits}{PW\ of\ Cost} \tag{8}$$

Based on the calculation of the cost and benefit components, the net present value, internal rate of return, and benefit-cost ratio values were obtained. The results were analyzed using a cost-benefit analysis based on the provisions of the feasibility criteria of each component to determine the feasibility of planning an organic waste processing technology.

3. Results and Discussion

3.1 Solid Waste Generation

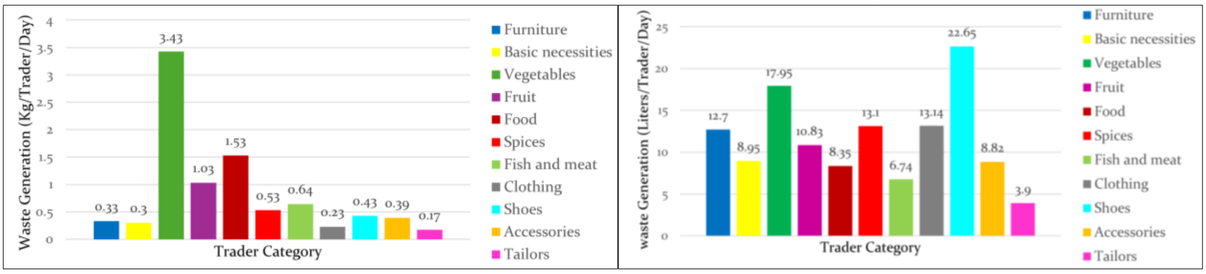
Figure 2 presents a graph of waste generation during the 8-day sampling period. The total weight of waste generated during the sampling period was 316.83 kg, with an average of 39.60 kg/day.



(A) Waste Generation Based on Wight (Kg/day) (B) Waste Generation Based on Volume (Liter/Day)

Figure 2. Natar Market solid waste generation during sampling

Solid waste generation on the first, seventh, and eighth days of increased trading activity at the Natar Market occurred on Saturdays and Sundays. Research in the Bojonegoro Market indicates that increased waste generation occurs on Saturdays and Sundays because people have more time to shop (Afrianisa et al., 2023). Based on the measurement results presented in the form of a graph in Figure 3, the average weight of Natar Market waste per trader category was 1.45 kg/trader/day, with a total generation of 884.45 kg/day. The total volume of waste during the sampling activities was 2,857.45 liters, with an average of 357.18 L/day. The daily waste generation volume is relatively stable compared to the average waste generation. The average volume of waste generated by all kiosks was 12.93 L/merchant/day, with a total waste generation of 7,902.33 L/day. On average, there was a considerable difference in the amount of waste generated by each trader type. The waste generation rate in the Natar Market is lower than that in the Bojonegoro Market, with a generation weight of 1.55 kg/trader/day (Afrianisa et al., 2023). This figure shows the difference in the number of trader stalls and market areas. Based on the average volume of waste, the type of goods and packaging used affects waste volume.

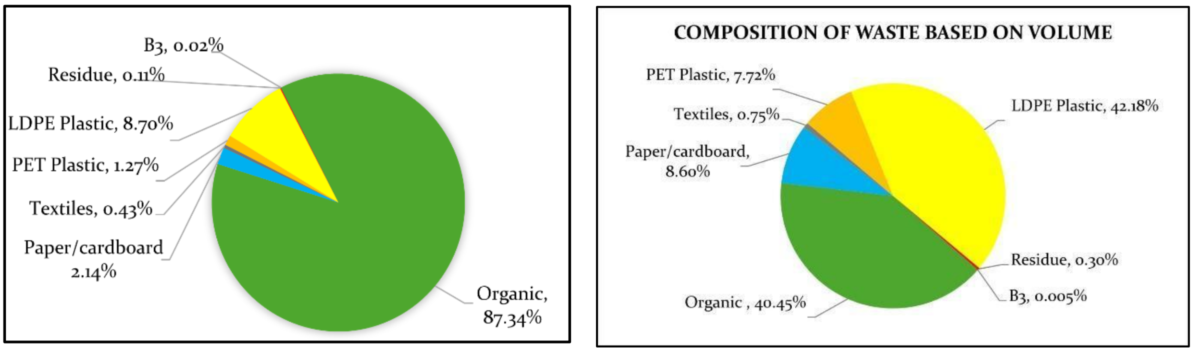


(A) Waste generation based on the weight of each category of traders (B) Waste generation based on volume for each category of traders

Figure 3. Natar Market solid waste generation based on merchant category

3.2 Solid Waste Composition

The weight percentage of organic waste is higher because the Natar Market is dominated by 313 traders, including all types of vegetable, fruit, spice, fish, and meat traders. The dominant organic waste needs to be appropriately handled using waste management technologies such as *black soldier fly, windrow composting,* or *vermicomposting.* The use of plastics as packaging materials and the consumption of soft drink products with plastic packaging are relatively high. The sorting results showed that PET and LDPE bottles dominated the plastic waste components. Paper/cardboard waste is generated by traders of groceries, shoes, and accessories. Residual waste is generated by the activities of traders who consume cigarettes, and hazardous waste consists of used batteries that are not related to the goods sold. From the measurement results, the total density of waste was 2009.46 kg/m3, with organic waste of 186.835 kg/m³.



(A) Composition of waste based on weight (B) Composition of waste based on volume

Figure 4. Solid Waste composition of Natar Market

3.3 The Result of Scoring and Weighting Analysis of Organic Waste Processing Technology

After collecting data from each subcriterion, scoring and weighting calculations were performed for each waste treatment technology. Based on the weighting results, the scoring and weighting values of the three technologies were 418, 262, and 313, respectively. The highest scoring and weighting values were obtained for BSF technology, whereas the lowest values were obtained for windrow composting and vermicomposting technologies. From the technical criteria, BSF technology had the highest score in the selection of alternative organic waste treatment technologies. BSF technology is easier to operate than the other two technologies, as indicated by its high score on the technical criteria.

The environmental subcriteria showed that organic waste processing technology using BSF obtained a higher score than windrow composting technology, except for the subcriteria of CO_2 emissions generated from processing activities. This score indicates that BSF technology has the least environmental impact. Windrow composting technology causes environmental problems, particularly air pollution generated by CH_4, CO_2, and N_2O emissions. The subcriteria for vegetable, fruit, food waste, fish, and meat waste produced different scores. These differences indicate that the waste type affects the processing results. The sub-criteria for waste mass reduction showed that BSF technology was higher than other technologies, indicating that this technology can reduce the most waste volume.

BSF technology has higher NPV, IRR, and BCR values than vermicomposting technology, but all three alternative waste treatment technologies using BSF, windrow composting, and vermicomposting meet the economic feasibility criteria, as indicated by NPV, IRR, and BCR values that meet the requirements for decision-making in a waste treatment project. The scoring and weighting results from the social criteria showed that waste treatment using BSF technology creates more job opportunities for the community. The scoring and weighting values of BSF technology were higher in the sub-criteria of low disturbance to the community. These values indicate that BSF technology has better control over disturbances, such as odors.

3.4 Solid Waste Mass Balance

The recovery factor values of organic waste, paper/cardboard, and plastic were 80 %, 40%, and 80%, respectively, indicating that most of them can be reprocessed. Textiles, hazardous waste, and residues have a recovery factor of 0% because these waste components cannot be managed and processed (Damanhuri and Padmi, 2018; Smith and Williams, 2010).

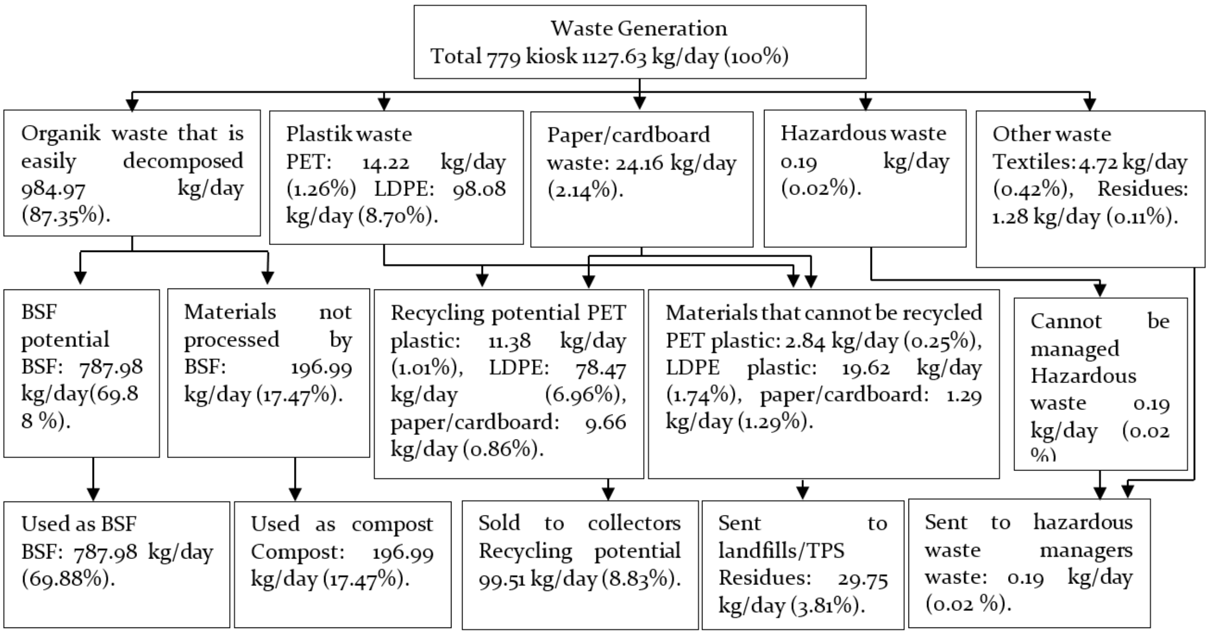


Figure 5. Waste balance at Natar Market

3.5 Facility Planning for Organic Waste Processing Technology

The planned Black Soldier reception and pretreatment unit requires a land area of 5 m2to temporarily store 984.97 kg/day of organic waste. The waste processing unit requires 636 containers for 12 days, with 18 shelves and a land area of 34 32 m^2. The hatchery unit is a place for hatching and breeding larvae, producing 103,448 eggs per container, and has a land area of 6.76 m^2. The rearing house is used as a residence for adult larvae that perform 70% of mating and produce eggs (Bsf et al., 2023). The rearing house requires nine units/9 days and a land area of 4.41 m^2/9 days. The pupation chamber is where prepupae turn into flies, with a larval presence rate of 80% (Bsf et al. 2023). The total number of pupation chambers and containers was 21 units/21 days, with a pupation chamber area of 11.81 m^2/21 days. The product harvesting unit, which uses black soldier flies for organic waste treatment, produces 454.56 kg/day of larval products and 264.29 kg/day of residue.

The layout plan for the waste management unit at Natar Market focuses on utilizing vacant land within the market area to minimize land acquisition costs and reduce waste transportation expenses. This strategy implements an efficient zoning system, starting from the reception and sorting area at the front to facilitate logistics access, a mechanical shredding room, and a semi-enclosed bioconversion-based processing core zone designed to maintain air circulation while preventing odors from disturbing the trading area. By integrating a watertight drainage system throughout the facility's floors, this layout not only ensures daily operational efficiency but also creates an economical self-managed system without disrupting the comfort of trading activities in the market.

3.6 Economic Potential Data Collection

The types of PET plastic waste found during sampling activities were clear white, LDPE plastic, and cardboard, with an economic potential of Rp. 2,151,796.50 kg/year. The total cost is Rp. 59,720,082,622.32 for 30 years. The benefit component from product sales income is Rp. 1,594,569,911.49 per year, and the retribution is Rp. 420,660,000.00 per year. The indirect benefit component of reducing CO_2 emissions from waste transportation was Rp. 1,826,951.29, and CH_4 emissions at the landfill are Rp. 26,092,115.51. The author uses the United States Environmental Protection Agency (US EPA) 2017 price approach to analyze the costs and benefits in the public sector (Government, 2015).

The investment in this project showed an NPV of USD 31,490 over 30 year,s with a social discount rate of 5.50%. The NPV and IRR values generated in this study are lower than those of the

Tunas and Balaraja Units (Bahtiar and Kamelia, 2023). The IRR rate of return obtained was 12% greater than the social discount rate of 5.50%. Differences in project scale, cost assumptions, revenues, and discount rates used in the calculations affect the results. The BCR obtained was 1.017, which was greater than 1. The BCR value in this study is lower than that of the previous study in the Tunas and Balaraja Units (Bahtiar and Kamelia, 2023). There are differences in the benefits and costs, as well as the size and capacity of processing. Positive NPV, IRR, and BCR values indicate that the planned treatment facility will generate significantly greater benefits and is economically acceptable.

4. Conclusion

The total solid waste generation of Natar Market based on merchant category is 884.45 kg/day and 7902.33 L/day. The composition of waste in Natar Market by weight is dominated by organic waste 87.35%, followed by paper/cardboard 2.14%, textile 0.42%, PET plastic 1.26%, LDPE plastic 8.70%, residue 0.11%, and B3 0.02%. The composition of solid waste in Natar Market by volume was 42.18% LDPE plastic waste, 40.45% organic, 7.72% PET plastic, 8.60% paper/cardboard, 4.80% textile, 0.40% residue, and 0.005% B3. Black soldier fly technology is the selected alternative technology for processing organic waste in the Natar Market. The economic potential of the recycled waste in the Natar Market is Rp. 2,151,796.50. The planning of organic waste treatment technology using Black Soldier in Natar Market is acceptable to implement, as indicated by the Net Present Value of Rp. 497,543,239.61; Internal Rate of Return 12%; and Benefit Cost Ratio 1.017.

Acknowledgments

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Ethics Statement

This study did not involve animals or sensitive data; therefore, no ethical approval was required.

CRediT Author Statement

Shintia Nur Asiah: Idea Development, Research Design, Formal Analysis, Investigation, Data Curation, Manuscript Draft Preparation, Visualization. **Suci Wulandari:** Idea Development, Research Design, Formal Analysis, Manuscript Draft Preparation, Supervision, Financial Support Acquisition. **Aulia Annas Mufti**: Research Design, Formal Analysis, Supervision, Financial Support Acquisition. **Andika Munandar**: Result Verification, Formal Analysis, Financial Support Acquisition. **Nabila Putriyandri Alifa**: Result Verification, Resources, Financial Support Acquisition. **Alien Abi Bianasari**: Manuscript Review and Revision, Financial Support Acquisition.

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