Mitigation Strategies and Economic Potential of Waste Resource Recovery in Banjarbaru City, South Kalimantan

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Abstract: *The global challenge of municipal solid waste management (MSW) has reached a critical turning point, requiring urgent action from cities worldwide. Banjarbaru, Indonesia, as the dynamic capital of South Kalimantan, also needs to take action to address MSW-related problems. Official data indicate that approximately 191 tonnes of MSW are generated per day, and this amount will increase exponentially as the city grows. This study aims to project waste generation through 2030, identify waste recovery strategies focused solely on organic waste and high-value recyclables, and assess their economic potential. The method used in this study is the bottom-up estimation method, which is the standard for waste management feasibility studies. Waste generation is projected to grow exponentially to approximately 257 tonnes per day by 2030. There is a lucrative annual revenue stream of IDR 30.6 billion from improved waste management in Banjar Baru, South Kalimantan. This potential can serve as an alternative to the waste management challenge and help transform it into a circular economy model.*

Key Words*:* BSF, economic, generation, maggot, recyclable, waste

Introduction

The rapid growth of global urbanization and economic development has exacerbated a parallel, yet often overlooked, problem: the exponential increase in municipal solid waste (MSW) (Sharma & Jain, 2020; Wilson, Rodic, Scheinberg, Velis, & Alabaster, 2012). Once a localized concern, solid waste management has evolved into a complex issue with profound implications for environmental, public health, and economic stability. According to the United Nations Environment Programme's *Global Waste Management Outlook 2024*, global MSW generation is projected to surge from approximately 2.3 billion tonnes in 2023 to 3.8 billion tonnes by 2050 (UNEP, 2024). This growth, primarily driven by population growth and shifting consumption patterns in emerging economies, threatens to overwhelm existing infrastructure and worsen the already critical levels of pollution affecting the biosphere.

The same problem is also experienced in Indonesia, where rapid economic expansion and urbanization have accelerated. The MSW management has emerged as one of the most critical environmental challenges (Gezelius & Torstensson, 2015; Mulasari, Rustiawan, Dahlan, & Info, 2018; Potdar et al., 2016). The national landscape is characterized by a disparity between waste generation rates and the capacity of the infrastructure to handle waste; despite the government's ambitious target to reduce waste by 30% and properly handle 70% by 2025, progress has lagged (Antara News, 2025; Kompas, 2024). Data show that Indonesia generates 30-40 million tonnes of waste annually, with the vast majority ending up

in landfills (Tempat Pemrosesan Akhir, or TPA) that operate primarily as open dumps or controlled landfills rather than sanitary ones (NPAP, 2020; The World Bank, 2023). This dependence on open dumps or controlled landfills is increasingly creating the problem, as land scarcity and environmental damage threaten the resilience of urban centers across the nation.

This national crisis is reflected in Banjarbaru City, the capital of South Kalimantan Province. As a growing administrative and residential hub, Banjarbaru faces intensified pressure on its waste management systems due to population growth and changing consumption patterns. Recent data indicate that the city generates approximately 191 tonnes of waste daily (roughly 0.71 kg per person/day), a volume that is steadily eroding the capacity of the city's primary disposal site, Gunung Kupang landfill (TPA) (Pahruddin, As, & Days, 2025). The situation at Gunung Kupang landfill represents a critical barrier to the city's progress toward sustainability. With over 12 of its 17 hectares already in use, the facility is rapidly approaching its maximum lifespan. It is estimated to remain viable for only another 5 years without significant intervention (Bakabar.com, 2025).

Furthermore, the composition of Banjarbaru's waste is dominated by organic matter at 46.94% food waste and 16.11% garden waste, followed by inorganic waste, which poses special management challenges, particularly regarding methane emissions and leachate management, in a region where heavy rainfall occurs year-round (Atthaya, Yulianto, & Warmadewanthi, 2025). While the city has implemented some actions to reduce the processing of the waste at the landfill, where a reduction of 28% was made, and the remaining 72% was left for processing at the landfill (DLH Kota Banjarbaru, 2025), the amount of waste dumped at the landfill is still massive enough. It grows exponentially, directly proportional to population growth.

Addressing these challenges requires a solution that is simple enough but sufficient to overcome the problems in Banjarbaru's city waste management. Therefore, this paper examines and identifies strategies to overcome the capacity limitations of Gunung Kupang landfill in Banjarbaru and simultaneously assesses the economic potential of the implemented methods. There are handful of studies related to waste problem faced by Banjarbaru city, where most of the studies discussed about the challenge face by Banjarbaru city related to its waste generation, waste volume analysis, waste reduction policy constraint, evaluation of Banjarbaru's landfill and its sustainable solution, and role of waste bank as one of the approach to reduce waste consumption and at the same time gives education and awareness on environmental issue pertinent to waste (Atthaya et al., 2025; Cahyono, Amrullah, & Ansyah, 2023; Manruni, Mahyudin, Achmad, & Mahyudin, 2023; Pahruddin et al., 2025; Ulimaz, 2019).

Atthaya et al. (2025) evaluate the existing environmental conditions of Gunung Kupang landfill and determine necessary follow-up actions. Using the ARRPET method, Gunung Kupang landfill has a moderate ecological risk. Immediate rehabilitation of the landfill into a sustainable landfill is recommended. Proposed rehabilitation methods were found to be financially feasible.

Ulimaz et al. (2019) studied household waste generation in North Banjarbaru District and determined how proper waste management can be implemented in that region. The average household waste volume in North Banjarbaru District is 0.49 kg/capita per day. The waste transportation facility provided is the bare minimum, with only two garbage transport trucks available. In comparison, the minimum requirement is seven trucks, which the city sanitation department should provide.

Manruni et al. (2023) study and analyze the current conditions of waste reduction and handling in Banjarbaru City, and examine the constraints posed by the existing Regional Policy and Strategy (Jakstrada). The Jakstrada targets for 2025 were not met in 2022, and the primary constraint in the planning component is government policy.

Pahruddin et al. (2025) provided a comprehensive picture of waste generation, composition, and community behavior in waste management. This study used surveys and questionnaires. The study's findings highlight the importance of collaboration between the government and the community as the main stakeholders to create a sustainable solution. Implementing programs like waste banks helps reduce the burden on landfills. However, the infrastructure challenge and community awareness need to be addressed.

From several studies conducted on waste issues in Banjarbaru city, there is still a lack of studies that address real, bottom-up, community-based solutions to mitigate and reduce waste through simple implementation methods, such as the utilisation of black soldier fly (BSF) maggots and the recycling of plastic and other recyclables (Ferronato, Paoli, Romagnoli, Tettamanti, & Bruno, 2024; Potdar et al., 2016; Salam, Shahzadi, Zheng, Alam, & Bilal, 2022; Sharma & Jain, 2020). There is also a lack of studies on the economic potential of waste generated in Banjarbaru city. Consequently, this paper aims to evaluate and propose a community-based mitigation strategy model and the economic potential of waste reduction in Banjarbaru's city, and ultimately, this strategy can be utilised in other cities with similar problems.

Method

The methods used were: 1) Forecast of the waste generation up to the year 2030; 2) Find mitigation strategies and estimation of economic potential from waste reduction in the year 2030

Forecast of Waste Generated

The forecast method for estimating waste generation in 2030 was implemented in Microsoft Excel using the Forecast function. The data used for forecasting are presented in Table 1 and were obtained from the National Waste Management Information System (SIPSN) (“SIPSN - Sistem Informasi Pengelolaan Sampah Nasional,” 2025).

Table 1. Waste Generation in BanjarBaru city from 2020 to 2024

Year	Waste Generation (tonnes/day)	Waste Generation (tonnes/year)
2020	147	53,700
2021	165	60,120
2022	184	67,080
2023	186	67,854
2024	191	69,691

The waste generated and delivered to Gunung Kupang landfill was only 72% in 2024, equivalent to 50,049 tonnes (DLH Kota Banjarbaru, 2025). Waste is reduced in the community through the Reduce, Reuse, and Recycle Waste Processing Site (Tempat Pengolahan Sampah Reduce, Reuse, and Recycle, TP3SR). The further target for reducing waste delivered to TPA is expected to be at least 50% of the current waste generation capacity (Dahliana, 2025).

Mitigation Strategies and Estimation of Economic Potential

The mitigation strategies proposed were drawn from several literature sources on BSF and the recycling of materials with economic value. Table 2 provides the sources of mitigation strategies and the parameters used to calculate the economic potential of reduced waste. Table 2 consists of mitigation strategies and the values used for the economic potential calculation. The prices of BSF maggot and recyclables per kg are based on the references listed in Table 2.

Table 2. Parameter for Mitigation Strategies and Economic Potential Calculation

Parameter	Value	References
Organic Valorisation Mitigation Strategy using BSF	conversion rate to maggot assumed at 15% (10 kg organic waste for 1.5 kg maggot)	(Ferronato et al., 2024; Potdar et al., 2016; Salam et al., 2022; Sulastri, Lisdiana, & Yuwono, 2025)
Mitigation Strategy by recycling	Recycling of plastic and other recyclables is standard to reduce non-biodegradable waste.	(Hakim, Martono, & Agustina, 2024; Oka Lesmana S & Fajrina Hidayati, 2024; Prasaningtyas, Rini, Basransyah, Harfadli, & Rachmannia, 2025)
Price of BSF maggot per kg	IDR 7,000	(Sulastri et al., 2025)
Price of recyclables on average (plastic, etc) per kg	IDR 2,500	(Yanto, Aqfir, & Fatima, 2023)

The waste reduction target for 2030 is assumed to be around 50-51% by 2024 (Dahliana, 2025). The waste delivered to landfill was only 72%, and it was believed that this value would remain the same in 2030. Table 3 shows the composition of waste generated in Banjarbaru city (Atthaya et al., 2025).

Table 3. Composition of Waste Generated in Banjarbaru City

Waste Type	Composition (%)
Organic/Food Waste	46.94%
Garden waste	16.11%
Plastic	13.59%
Paper and cardboard	3.84%
Others (Textile, Glass, Metal, Residue):	19.52%

The primary strategy to reduce waste in landfills is to target organic waste, mainly food waste, and inorganic recyclable waste (RW) such as plastic, paper, and cardboard.

The economic potential of reducing organic waste and inorganic waste was calculated using (1) and (2).

$$LBSF_{Revenue} = Y_{LBSF}\ x\ P_{LBSF} \quad (1)$$

$LBSF_{revenue}$ stands for revenue coming from the sales of maggot of BSF cultivated in IDR/day, Y_{LBSF} is the yield of BSF obtained in kg/day, and P_{LBSF} is the Price of BSF maggot in IDR/kg.

$$RW_{Revenue} = m_{RW}\ x\ P_{RW} \quad (2)$$

$RW_{revenue}$ is revenue from the sale of recyclable waste in IDR/day; m_{RW} is the quantity of recyclable waste in kg/day; P_{RW} is the price of recyclables in IDR/kg.

Results and Discussion

Waste Generation Projection in Banjarbaru City

The projection of waste generated in Banjarbaru city up to 2030 is shown in Figure 1.

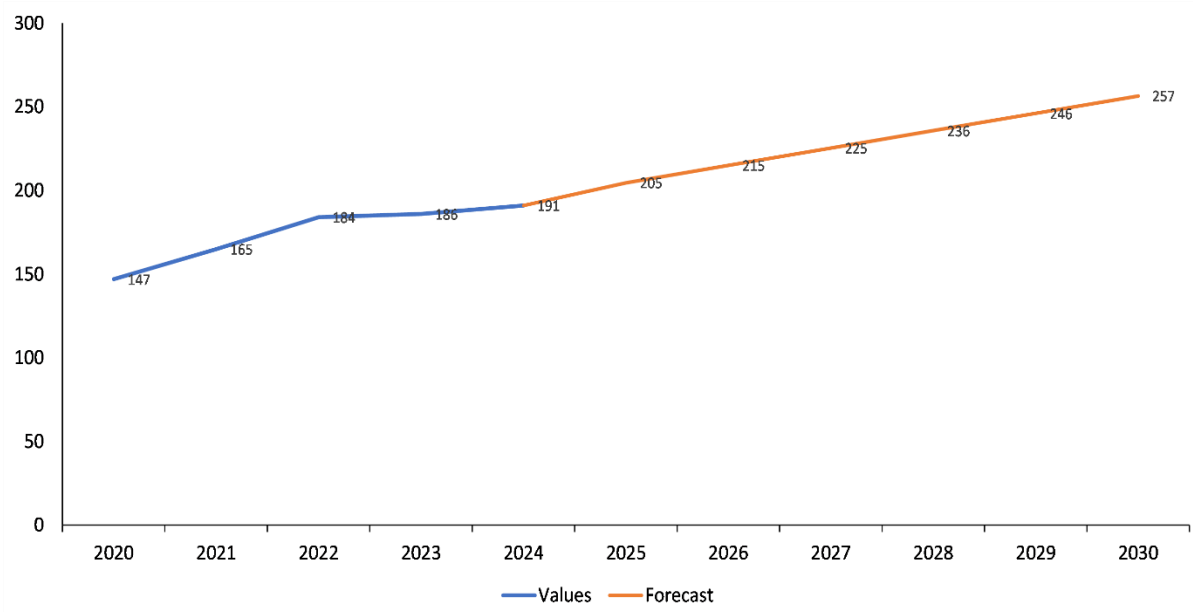

Figure 1. Forecast of Waste Generated in Banjarbaru City up to 2030

Figure 1 displays the forecast of waste generated in Banjar Baru city in 2030 based on daily generation data from 2020 to 2024. The waste generated steadily increased, and there was a significant jump from 2020 to 2021 of 12%, likely reflecting the resumption of activities after COVID-19 Pandemic restrictions. From 2021 to 2022, the waste generation rate remained high at 11.5%, further indicating the continued resumption of activities after the COVID-19 Pandemic restrictions, though at a lower growth rate. Then, from 2023 to 2024, the rate is lower, with steady growth at 2.6%. By 2024, waste generation in Banjarbaru city was growing rapidly, up 30% from 2020. This growth is enormous, and if no further action is taken to anticipate future growth, the landfill will not be able to handle the waste, and Banjarbaru city will need to find a new landfill, which is not an easy process and takes years to plan and

execute. At present, the landfill in Banjarbaru city is still capable of handling waste for at least another 5 years (business-as-usual, BAU). To prolong the use of the Gunung Kupang landfill, waste volumes need to be reduced. The targeted waste received at the landfill aims to achieve at least 50% of its current generation capacity (Dahliana, 2025). The estimated waste in 2030 is 257 tonnes/day, an increase of about 66 tonnes/day from 2024. This growth represents a roughly 34.6% increase in daily waste generation up to 2030. If the current practice of reducing waste at source by around 28% were to continue, the waste generated would still be significantly high. If current trends in population growth and consumption habits continue without interventions, landfill capacity could be overwhelmed. The city of Banjarbaru needs to manage an additional 66 tonnes of waste per year by 2030, compared to 2024. To flatten the projected 2030 waste generation curve, Banjarbaru needs to intervene primarily in the two largest waste categories: organic (food waste) and inorganic (Plastics and cardboard).

Mitigation Strategies and Economic Potential Estimation

In addition to the existing waste-reduction practice, which reduces waste at TPS3R and composts it (DLH Kota Banjarbaru, 2025), other mitigation strategies targeting organic and plastic waste are proposed.

Since 46.94% of Banjarbaru's waste is food waste, or around 120.64 tonnes/day in the year 2030 waste generation projection, solving this single problem reduces the landfill load by almost half of the waste generated in 2030. The mitigation strategy to target organic waste uses BSF maggots. BSF maggots can be used to consume organic waste. So far, BSF maggots have been highly effective at consuming and decomposing organic waste, especially in tropical regions such as South Kalimantan. A BSF maggot at 1 kg can consume 2 to 5 kg of organic waste per day (Farinduan & Samosir, 2023; Haqqi et al., 2023). BSF maggots are a valuable commodity, primarily used as high-protein feed in the local fisheries industry (Barragán-Fonseca, Cortés-Urquijo, Pineda-Mejía, Lagos-Sierra, & Dicke, 2023).

Another strategy is to strengthen the existing Waste Bank (Bank Sampah) infrastructure, which needs to be updated and scaled to keep pace with population growth (Rubiyannor, Abdi, & Mahyudin, 2016; Syaharuddin, Hidayanti, & Mutiani, 2020). The waste bank must have a central waste bank that acts as an off-taker of waste from the community. The primary focus of this central waste bank is to sort high-value plastics and cardboard. The partnership with the local recycling collector is also needed to ensure that the collected materials are recycled. Figure 2 compares the amount of waste produced under the business-as-usual (BAU) scheme and under an intervention/mitigation scenario in the year 2030.

Figure 2. Comparison of BAU versus Scenario with Intervention/Mitigation Strategies

Based on Figure 2, waste generation is the same for both BAU and the scenario with additional interventions/mitigations in 2030, at 257 tonnes per day. The difference is quite apparent: in the BAU scenario, the gray bar shows a massive 185 tonnes/day of waste sent to the Gunung Kupang landfill, while the diverted waste is 72 tonnes/day. This BAU scenario leads to rapid waste accumulation, highly likely to exhaust the landfill's capacity by 2030. The scenario with extra interventions/mitigations shows that the gray bar shrinks to 126 tonnes/day, below the 2020 waste generation level, effectively resetting the landfill capacity below 2020 levels and giving more time to operate the landfills. There are 72 tonnes/day of waste diverted (same as the BAU scenario), and an additional 59 tonnes/day of waste diverted (organic and inorganic), which comes from 46.94% organic food waste and 17.43% inorganic waste (plastics and cardboard) of the waste to be reduced. An additional 59 tonnes/day of waste and 72 tonnes/day of diversion represent 51% of the waste reduction potential, and only 49% of waste is delivered to landfill. The results are a game-changer, as the worst part of the waste (organic waste) can be turned into a valuable product through BSF maggot farming.

If Banjarbaru city successfully diverts the additional 59 tonnes/day (43 tonnes of organic waste and 16 tonnes of inorganic waste) by 2030, the economic potential is enormous, and the landfill burden is reduced. Table 4 displays the estimated economic potential based on current average market prices in Indonesia for the additional waste diverted.

Table 4. Economic Potential for Waste Diverted/Reduced in 2030

Revenue Stream	Daily Value (IDR)	Monthly Value (IDR)	Annual Value (IDR)
Maggot Feed (Organics)	45,150,000	1.35 Billion	16.2 Billion
Recyclables (Inorganic)	40,000,000	1.20 Billion	14.4 Billion
TOTAL	**85,150,000**	**2.55 Billion**	**30.6 Billion**

From Table 4, it is clear that both organic and inorganic waste, with high revenue potential, though profitability can vary, depend on operating costs. Labor costs are the most significant contributor to overall operating costs (Koes, Hardini, & Gandhy, 2020; Susilowati, Bachtiar, & Sarinastiti, 2024; Zahra & Sari, 2025; Ziad, Khan, Ali, & Inayat, 2025).

Banjarbaru and the surrounding South Kalimantan region have strong fisheries and poultry industries (Aisyah, Khotimah, Rahmawati, Candra, & Hardiyanti, 2025; Ripner, Tenri Sompa, & Yunani, 2021). This cultivation of BSF maggot creates a high demand for alternative protein feed. The protein requirement can be met by the BSF maggot, which rapidly consumes organic waste. With a conversion rate of 10 kg of organic waste into 1.5 kg of fresh BSF maggot, the fishery and poultry industry can capitalize on this abundant feed supply of BSF maggot. Estimated revenue from BSF maggot cultivation is IDR 16.2 billion per year. It is estimated that the profit margin of BSF maggot cultivation is as high as 65%, by assuming that the operating cost of this BSF is IDR 2,477 per kg (Koes et al., 2020); hence, the profit of BSF maggot cultivation is at IDR 29.17 billion per year.

The economic potential of inorganic materials such as plastics and cardboard is also promising, with waste banks collecting high-value waste such as PET bottles, HDPE, and cardboard, and selling it at an average price of IDR 2,500 per kg (a mixture of high-value plastic waste and cardboard). The economic potential is estimated at IDR 14.4 billion in annual revenue for the community that collects and delivers waste to the available waste bank. Waste banks must also aggressively promote their activities and the value of the recyclable materials they collect to the community. The implementation of high-tech sorting and collection systems is needed and can be achieved with proper support from the Banjarbaru city government.

The above economic potential represents theoretical gross revenue and can serve as a starting point for a further economic feasibility study of waste handling. The gross profit estimate for BSF maggot cultivation was based on the organic material to be purchased; in this case, the operating cost could be lower since the organic material is freely available. The mitigation strategies proposed in this study shift waste management from capital-intensive activities, such as hauling and dumping, to labor-intensive activities, such as sorting and farming. Processing an additional 59 tonnes of waste daily could create dozens of local jobs in sorting centers and BSF maggot farms. There is potential for synergy among the fisheries,

poultry, and BSF maggot farming industries, primarily to provide cheap feed and reduce reliance on expensive commercial pellets.

Conclusion:

Banjarbaru city faces waste-related problems, as do other cities in Indonesia and most cities worldwide. The projection of reaching 257 tons of waste per day by 2030 poses a threat to the city's landfill (TPA Gunung Kupang) capacity. However, this threat can be addressed through appropriate measures to eliminate or minimize it. The data collected demonstrate that the dominant composition of the waste, organic waste, is a highly valuable asset. Some inorganic waste, such as plastics and cardboard, is also a valuable resource. By aggressively shifting from a BAU disposal model to a more aggressive model through the commercialization of organic and inorganic waste, Banjarbaru city not only averts a landfill crisis but also unlocks an economic sector worth over IDR 30.6 billion annually. The integration of BSF maggot cultivation and Waste Banks allows the city to decouple population growth from waste generation, ensuring a sustainable future for Banjarbaru, the capital of South Kalimantan.

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