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Applying Circular Economy Principles to Strengthen Organic Waste Management Using BSF Maggots in RW 02 Jamaras, Bandung, Indonesia

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Abstract

A waste processing program in Bandung is urgently needed to reduce the large volume of waste transported to the overburdened Sarimukti landfill. To respond to this challenge, the Bandung City Government promotes source-based organic waste treatment using BSF larvae as a key bioconversion strategy. This community service initiative sought to strengthen neighborhood-level organic waste management, with a targeted focus on RW 02, Jatihandap Village. The Environmental Engineering Team from LPPM ITB applied an integrated approach that combined awareness campaigns, assessment of waste generation and composition, and improvements to on-site processing infrastructure. Field sampling showed that approximately 51.7 kg of household waste is produced daily by 53 participating households in the Watesa Jamaras initiative. However, space and equipment constraints limit the capacity of the BSF system, requiring the community to supplement treatment with overlay brick composting and bucket composting, both of which yield modest economic benefits. After program implementation, residents successfully optimized BSF cultivation, raised chickens and fish using BSF larvae as feed, and produced vegetables using BSF-based fertilizer. Overall, the community now processes an estimated 8.37 tons of organic waste annually, preventing roughly 0.28 metric tons of CH_4 emissions per year. These outcomes demonstrate that a locally integrated BSF-based approach can significantly reduce environmental impacts while enhancing community-scale resource recovery. The study underscores the broader relevance of decentralized organic waste management models and highlights their potential contribution to sustainable urban development in rapidly growing cities.

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INTRODUCTION

On August 18, 2023, a fire broke out at the Sarimukti Landfill, triggering a waste management emergency in West Java. The Governor of West Java issued Instruction No. 02/PBLS.04/DLH, limiting residual waste intake to 50% and prohibiting the disposal of organic waste. This directive revealed the fragility of Bandung's prevailing waste management system, which still depends on the collect-transport-dispose paradigm. With approximately 70% of the city's daily waste, equivalent to 1,289 tons, sent to Sarimukti, and 58% of that being organic (Chaerul & Mardiyah, 2019), the need for decentralized and resilient organic waste treatment has become increasingly urgent. This aligns with global sustainability discourses, including SDG 11 and SDG 12, which emphasize resilient cities and reductions in waste generation through prevention, recycling, and recovery. Recent studies underscore the importance of locally adaptable solutions and community-scale interventions in accelerating circular practices across urban settlements (Hadfield et al., 2025; Theis, 2025; Lai et al., 2025).

At the policy and community level, the Bandung City Government has introduced small-scale organic waste technologies such as Kang Empos and Loseda (Chaerul & Zatadini, 2020). However, these interventions remain limited in scalability, cost-effectiveness, and long-term adoption. Black Soldier Fly (BSF) bioconversion has consequently gained attention as a promising alternative due to its potential for efficient nutrient recovery and higher revenue streams (Suhardono et al., 2024; Septiariva et al., 2023). Despite this progress, much of the existing literature still focuses on conceptual frameworks or rural contexts, leaving empirical assessments in dense urban kampungs insufficiently developed. The lack of systematic evaluations of neighborhood-scale BSF systems represents a critical gap, especially in settings with limited land availability, informal governance arrangements, and fluctuating waste characteristics.

To address this gap, the present study examines Jamaras, a densely populated neighborhood comprising RW 02 and RW 11 in Jatihandap Sub-District, where a community-based BSF facility is voluntarily operated by a five-member women-led informal group known as Watesa. Operating on a 300 m^2 plot, the initiative manages only 250 kg of organic waste per week due to spatial and infrastructure constraints. The maggots are sold at low economic value (IDR 8,000/kg), and the facility lacks essential features such as a weather-resistant roof and preprocessing equipment, affecting process stability and product quality. These challenges hinder broader circular economy opportunities, including local aquaculture, household feed substitution, and the direct agricultural use of frass as organic fertilizer.

The aim of this study is to evaluate the current operational performance of the Jamaras BSF facility, identify technical and socioeconomic bottlenecks, and propose targeted improvements to enhance organic waste management efficiency. This study contributes by documenting one of the few women-led BSF initiatives in a high-density urban settlement, clarifying key operational and behavioral constraints, and offering integrative recommendations to advance community-scale circular economy practices. By presenting an empirical case within a constrained urban environment, this research strengthens the evidence base for decentralized BSF systems and demonstrates how informal communities can play a pivotal role in supporting sustainable waste infrastructure aligned with national and global targets.

Table 1. Number of Waste Contributors in Relation to Total Population

RT	Total Population (Individuals)	Waste-Contributing Households in Jamaras (Units)
1	78	-
2	126	4
3	61	6
4	176	5
5	225	16
6	128	9
7	177	13
Total	971	53

A clear problem arises from the gap between organic waste generation in dense urban neighborhoods and the limited capacity of community-run BSF facilities. The study examines how a neighborhood-scale system can function under strict spatial, infrastructural, and socioeconomic constraints. The problem centers on assessing the current performance of the Jamaras facility, identifying technical, behavioral, and organizational factors that restrict throughput, and determining which interventions can improve waste reduction and resource recovery. This formulation positions the challenge as a systemic issue involving community practices, economic viability, and infrastructure readiness, while highlighting the need for reliable monitoring, operational strategies, and stronger community participation to long-term performance.

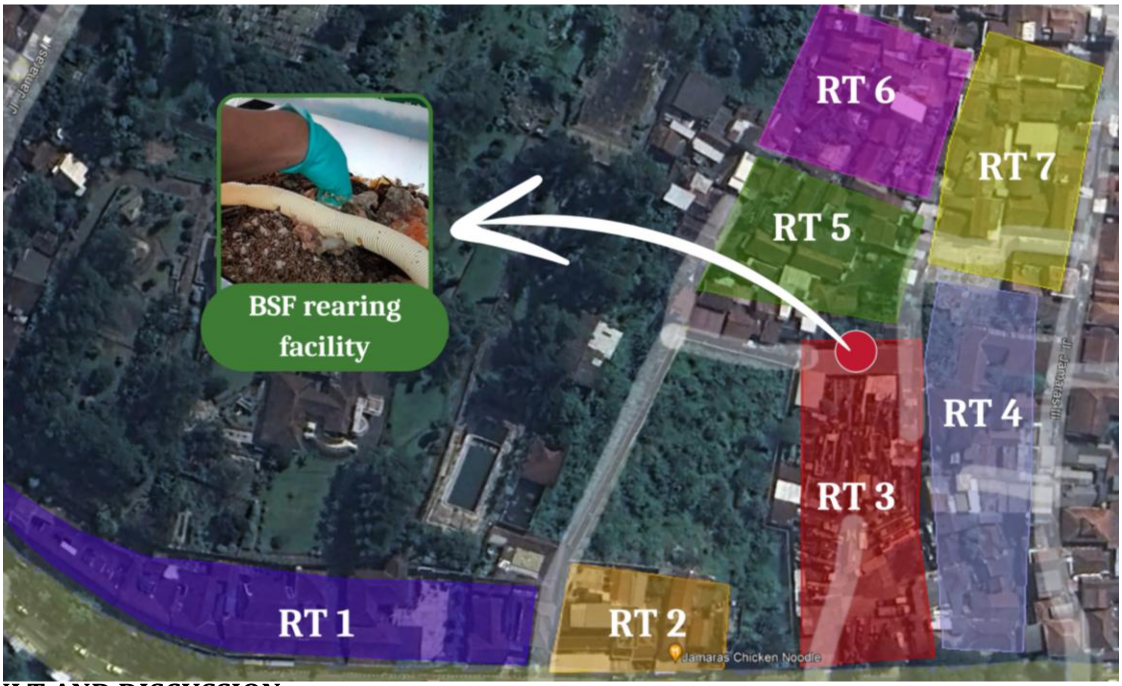
METHOD

This community engagement study was conducted in several interrelated stages to ensure a systematic and impactful implementation. The first stage involved preparation, including team formation and initial coordination with the local community in RW 02 Jamaras. Subsequently, problem identification and mapping were carried out through field surveys at the Jamaras area and the existing maggot house. This phase was supported by interviews and discussions with the local waste management group, Watesa, to understand current practices and challenges. Based on these findings, the problem formulation stage was conducted to define the study objectives and determine an appropriate implementation plan. The core implementation activities included sampling of waste generation and composition, laboratory-based waste characterization, improvement and development of the maggot house facilities, a formal inauguration, and continuous monitoring and evaluation. Waste sampling (see in Figure 2) and analysis followed the Indonesian National Standard (SNI 19-3964-1994) to ensure consistency and reliability, involving the collection and weighing of organic, residual, and recyclable waste, as well as calculating the generation rate per household. Laboratory analyses were conducted at the Solid and Hazardous Waste Laboratory, Environmental Engineering Department, ITB, using standardized procedures to characterize the waste (Table 2). The maggot house development included both structural and operational enhancements to improve waste bioconversion capacity. Finally, a comprehensive report was prepared based on the field implementation and data analysis, documenting the key activities, outcomes, and supporting evidence from the community engagement process.

Table 2. Waste Characterization Testing Methods

No	Parameter	Method
1	Moisture Content	ASTM D3173 - 03
2	Volatile Matter	ASTM D3172 - 07a
3	Ash Content	ASTM D3172 - 07a
4	Organic Carbon	SMEWW-5220-B
5	Total Kjeldahl Nitrogen (TKN)	SMEWW-4500-N_{ORG}*B

Figure 1. Waste Management Service Areas in Jamaras



RESULT AND DISCUSSION

Waste Generation and Composition in RW 02 Jamaras

Waste sampling activities in RW 02 Jamaras were conducted on July 2, 5, and 9, 2024, coinciding with the biweekly collection schedule coordinated with the local waste management unit, Watesa (see in Figure 2). The sampling aims to quantify waste generation and characterize composition to support improved treatment strategies. From the 53 households observed, the average daily waste generation was calculated at 51.7 kg/day. As illustrated in Figure 3a, organic waste remained the predominant category on all sampling days: 84.2 kg/day on July 2, 63.6 kg/day on July 5, and 83.0 kg/day on July 9. These figures indicate a high contribution of biodegradable materials, making up more than 60% of the total waste collected. Residual waste was the second most abundant category, spiking at 141 kg/day on July 2, possibly due to delayed collection or behavioral variations in waste disposal. Recyclables such as plastic, paper, and metal were relatively minor, with plastic ranging from 3.1–3.3 kg/day, paper from 0.5–6.4 kg/day, and metal peaking at 1.8 kg/day. Hazardous waste and rubber/leather materials appeared in trace amounts (<0.2 kg/day), suggesting low prevalence or underreporting due to limited household segregation. These data are consistent with Prakoso et al. (2020), who observed that organic fractions composed 65–75% of household waste in Yogyakarta. The observed pattern further reinforces the importance of treating organic waste at the source using biological methods such as BSF bioconversion. Compared to the study by Lalander et al. (2015), where maggot-based systems succeeded in reducing organic waste by 70%, the conditions in Jamaras also demonstrate high potential for decentralizing organic waste treatment to ease landfill dependency and increase local circular economic activities (Aji et al., 2024).

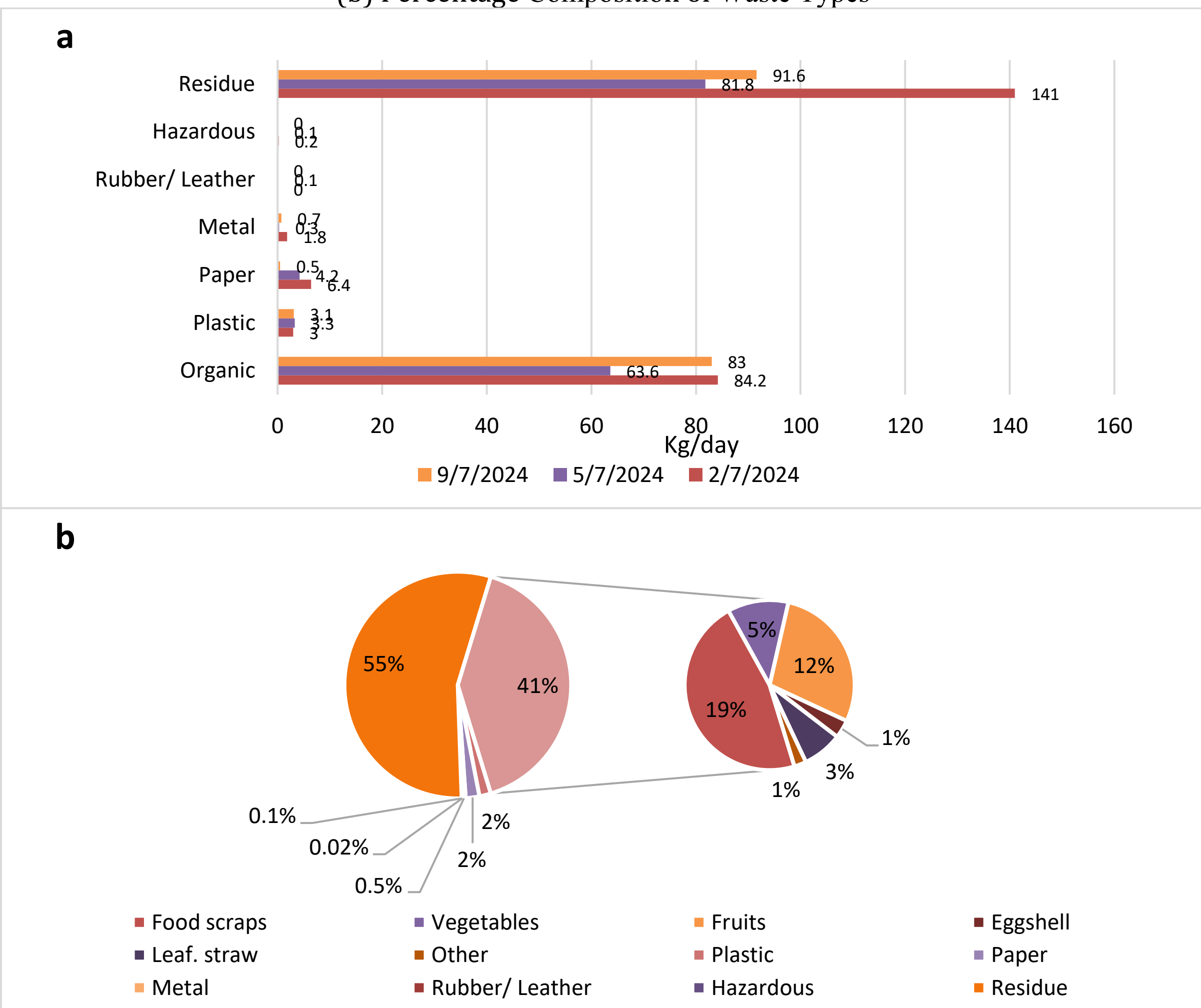
In-depth characterization of organic waste (Figure 3b) indicates that food scraps and vegetables made up 55% and 41%, respectively, while smaller fractions included fruit waste (2%), leaf/straw (0.5%), eggshells (0.1%), and others. This high biodegradability confirms the suitability of maggot bioconversion as a localized strategy, especially when spatial and financial constraints limit large-scale composting. The waste fraction also shows a minimal percentage of recyclable and hazardous waste, suggesting potential gaps in household waste sorting behavior. Compared to a similar maggot-based waste reduction study in Bekasi (Sukmawati et al., 2023), which successfully diverted 60–70% of organic waste with a daily treatment capacity of 20 g using BSF larvae, Jamaras still shows untapped potential. Optimizing existing infrastructure and raising awareness on household-level segregation could improve waste valorization outcomes. Moreover, integrating community-based models like waste banks and maggot farming can create economic value while alleviating landfill pressures, consistent with government efforts toward zero-waste communities. Therefore, this waste composition analysis supports the continuation of targeted education and technical interventions to maximize waste-to-resource recovery.

Physicochemical Characterization and Treatment Implications

Laboratory analysis of the collected waste samples was conducted at the Solid and Hazardous Waste Laboratory, Department of Environmental Engineering, ITB. The characterization focused on key physicochemical parameters, moisture content, volatile matter, ash content, total organic carbon, and TKN, particularly for the dominant organic and residual fractions. Based on laboratory results (Table 3), the organic waste exhibited a moisture content of 64.11%, indicating a moderately high-water content typical of kitchen and food-related waste. This value is slightly lower than that reported by Guo et al. (2012), who recorded 70–75% moisture for fresh household organics, yet still falls within the suitable range for BSF larvae substrate. The volatile matter reached 78.94%, suggesting a high degree of biodegradability, while the ash content was measured at 18.37%, which may reflect minor contamination by inert materials or soil particles. The organic carbon content was 55.21%, indicating that over half of the dry mass consisted of carbon-based compounds, a crucial parameter for assessing energy content and compost quality. Furthermore, the TKN value of 2.27% supports its nutritional adequacy for BSF feedstock, as nitrogen is essential for larval growth. Compared to similar studies conducted in urban areas of Yogyakarta and Bali, which found comparable organic compositions and physicochemical trends (Prakoso et al., 2020; Suryawan et al., 2023), the values in RW 02 Jamaras further validate the potential of maggot-based or composting interventions. In contrast, plastic waste, though not analyzed in full detail, exhibited low moisture content and is typically associated with high calorific value, reinforcing its applicability for energy recovery if infrastructure allows. Despite the low presence of hazardous waste (<0.5%), the identification of batteries and pesticide containers underscores the need for proper household segregation. Overall, these findings emphasize that standardized waste handling, combined with community-based sorting and valorization efforts, are vital for maximizing recovery while minimizing environmental risk (Widyarsana et al., 2025a; Widyarsana et al., 2025b).

Figure 2. Sampling Documentation

Figure 3. Composition of Waste (a) Quantity of Waste by Type in Each Disposal Period; (b) Percentage Composition of Waste Types



Estimated Waste Reduction to Landfill

Based on the average waste sampling results, approximately 23.24 kg/day of non-residual waste, comprising organic and recyclable materials, was successfully processed in RW 02 Jamaras. This amount, if maintained consistently throughout the year, equates to an estimated 8.37 tons of waste diverted annually from the Sarimukti landfill. Figure 4a illustrates the pre-existing condition of the maggot house, where inadequate roofing, limited storage, and rudimentary processing equipment constrained operational efficiency. In contrast, Figure 4b depicts the upgraded facility following intervention by LPPM ITB, with improved structural roofing, organized workspaces, BSF rearing boxes, and composting equipment that significantly boosted processing capacity and waste throughput. The waste reduction outcome in Jamaras is consistent with results from other community-based solid waste interventions. For example, Septiariva et al. (2021) reported a 32% annual reduction in landfill waste through an integrated BSF and composting system. Similarly, Lalander et al. (2015) observed a diversion through participatory waste segregation and maggot-based bioconversion. The case in Jamaras underscores the critical impact of infrastructure and technical support on scaling waste diversion outcomes. In addition, community training and active participation played a key role, echoing findings by Suryawan et al. (2023) that stakeholder involvement significantly improves waste treatment effectiveness in decentralized systems. The improvement in facility condition not only enhances organic waste processing but also strengthens the circular economy by enabling compost production and maggot harvesting for livestock feed, thus reducing environmental load and landfill dependency.

Table 3. Characteristics of Waste in Jamaras

No	Parameter	Result (% Dry Basis)
1	Moisture Content	64,11
2	Volatile Matter	78,94
3	Ash Content	18,37
4	Organic Carbon	55,21
5	Total Kjeldahl Nitrogen (TKN)	2,27

Potential Greenhouse Gas Emission Reduction from Waste Diversion

The diversion of organic waste from landfilling practices plays a vital role not only in reducing the volume of waste but also in mitigating GHG emissions, particularly CH_4, which is produced during anaerobic decomposition of organic matter in landfills. Based on the waste management activities implemented in RW 02 Jamaras, an estimated 8.37 tons of organic waste are diverted from landfills each year through BSF bioconversion and composting. Referring to the emission factor established by the US Environmental Protection Agency, which indicates that 1,000 tons of food waste disposed of in landfills produces approximately 34 metric tons of methane, the waste diversion in Jamaras is expected to prevent around 0.28 metric tons of CH_4 emissions annually. Although seemingly small in numerical value, this emission reduction becomes significantly impactful when viewed through the lens of the GWP of methane, which is 28–34 times greater than that of CO_2 over a 100-year period. In similar decentralized waste initiatives, Nguyen et al. (2021) in Vietnam reported a methane reduction of 0.33 tons per year from composting 10 tons of organic waste, while González-Lara et al. (2024) and González-Lara et al. (2025) documented a reduction of 0.25–0.4 tons of CH_4 annually in a community-scale BSF project in the Philippines. These comparisons validate the relevance of the Jamaras model in contributing to climate mitigation goals through low-tech, high-impact interventions. Scaled across similar peri-urban communities, such waste diversion efforts could form a meaningful part of national strategies for emission reduction and sustainable development, and encouraging broader community participation in sustainability initiatives while also fostering practical environmental awareness, strengthening local capacity, and supporting collaborative actions that reinforce long-term circular economy practices.

Waste Management Scheme with the Circular Economy Concept in Jamaras

The waste management scheme developed in RW 02 Jamaras exemplifies an integrated circular economy model, which begins at the household level through waste sorting into three main categories: organic, recyclable, and residual waste. As shown in Figure 5, waste collection is followed by weighing and sorting activities. Recyclable materials, such as plastic, paper, and metal, are transferred to collectors or waste banks for further processing, while residual waste that cannot be reused is transported to the Sarimukti landfill. The innovation of the Jamaras model lies in its multifaceted treatment of organic waste. A portion of organic waste is used as feed for BSF larvae, which is later harvested and utilized as high-protein animal feed for fish (catfish and tilapia) and poultry. This not only diverts organic waste from landfill but also creates economic and agricultural benefits. Another portion of organic waste undergoes composting using low-cost, community-accessible technologies such as ember tumpuk, ember tanam, and bata terawang, producing soil amendment media for urban agriculture within the Buruan Sae program. This localized circular flow enables waste-to-resource transformation with immediate impact on food security, household income, and environmental protection. The integration of used cooking oil into soap-making activities further extends the utility of household waste streams. The success of this model reinforces that sustainable waste management can thrive through community-driven initiatives supported by infrastructure, capacity building, and adaptive reuse practices, especially when communities adopt consistent monitoring, transparent coordination, and shared responsibility mechanisms to sustain long-term outcomes, ultimately strengthening local resilience and encouraging broader replication.

This scheme closely aligns with other successful implementations of circular economy principles in Indonesian cities. In Denpasar, for example, Septiariva et al., (2021) reported that a zero-waste community empowerment program reduced landfill waste by 40% annually by integrating BSF bioconversion, composting, and waste bank activities. Similarly, in Malang City, Mukti et al. (2021) documented a 60% increase in recyclable material recovery through community-based segregation and kitchen waste composting programs. However, what sets Jamaras apart is its hybridization of waste-to-feed and waste-to-soap strategies, which expand the economic value chain beyond compost alone. The inclusion of aquaculture and poultry farming using maggot feed strengthens the local food system while reducing dependence on commercial feed inputs. According to Alam et al. (2025), Prayogo et al. (2022a), and Prayogo et al. (2022b), the success of community-scale circular systems is highly dependent on participatory governance, local leadership, and continuous behavioral reinforcement, all of which are present in Jamaras, especially through the role of Watesa as the waste management facilitator. Moreover, the adaptability of composting techniques to small-scale urban conditions makes this model replicable in other dense settlements. In essence, the Jamaras waste management scheme not only exemplifies environmental innovation but also fosters a regenerative and inclusive approach to resource management, making it a valuable reference for policymakers and practitioners aiming to implement circular economy strategies at the community (Prakoso et al., 2020).

Efforts to Increase Waste Processing Capacity

To strengthen the capacity of community-based waste management in RW 02 Jamaras, a series of infrastructure improvements and equipment provisions were facilitated by LPPM ITB. These enhancements included the construction of a BSF fly enclosure, the installation of tiered larval growth racks, and the development of integrated fishponds and poultry coops. These facilities were inaugurated in a community ceremony, as depicted in Figure 6, marking a pivotal moment in transitioning from rudimentary to semi-structured waste processing systems. The BSF fly enclosure plays a key role in ensuring a sustainable life cycle for maggot production, while the growth racks optimize the vertical use of space for larval feeding. Simultaneously, the harvested larvae are used as feed in the adjacent fish and poultry systems, creating a circular loop that enhances the value chain of organic waste. This integrative model aligns with prior success stories, such as the Urban Bioconversion Project in Quezon City, Philippines, which demonstrated that combining BSF processing with aquaculture and poultry resulted in both waste reduction and protein production for food security (González-Lara et al., 2024; González-Lara et al., 2025). The strategic implementation in Jamaras reflects the increasing recognition that infrastructure is a critical enabling factor in grassroots environmental innovation, especially in peri-urban communities where land, resources, and institutional support may be limited.

Beyond physical infrastructure, the improvement efforts also included capacity building and knowledge transfer to the local waste management group, Watesa. Training on BSF rearing techniques, organic waste sorting, composting methods, and feed formulation was conducted to ensure the sustainability of the system. These interventions were inspired by similar community empowerment programs, such as the Zero Waste model in Denpasar, which reduced organic waste by up to 40% annually through simultaneous investments in equipment and community education (Septiariva et al., 2021). The integrated fish and poultry system in Jamaras not only increases the demand for maggot biomass but also opens income-generating opportunities for residents. In Malang, a circular waste management initiative reported that waste valorization through livestock integration improved economic resilience while maintaining environmental outcomes (Mukti et al., 2021). The combination of infrastructure development and technical assistance in Jamaras ensures that waste is not merely diverted but also transformed into valuable products, such as fish, poultry, compost, and soil media. These co-benefits reinforce the importance of system thinking in community waste management, where physical, social, and economic components interact dynamically. As a result, the Jamaras model serves as a replicable framework for other urban and peri-urban communities seeking to strengthen their waste management capacity through low-cost, high-impact solutions.

Figure 4. Existing Waste Management Conditions (a) Before Capacity Improvement (b) After Capacity Improvement by LPPM ITB

Figure 6. Inauguration and Provided Equipment

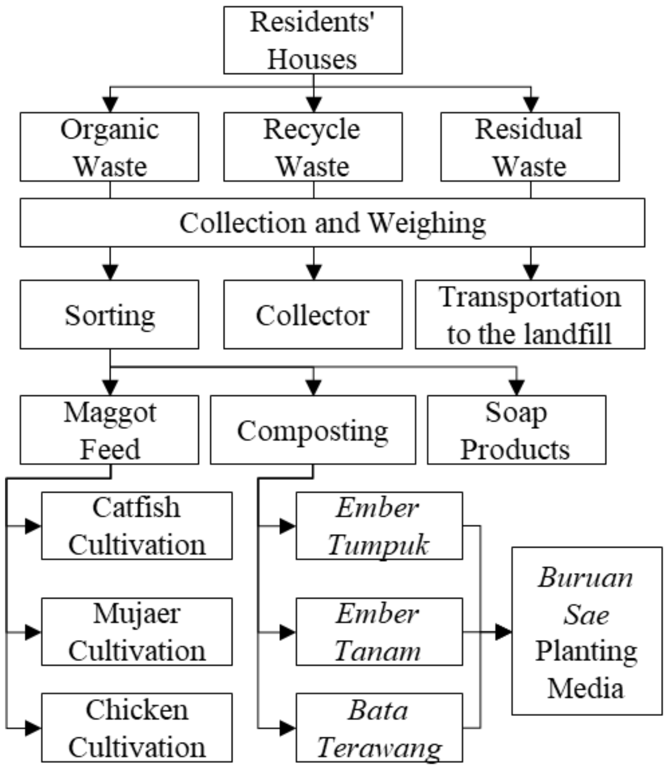


Figure 5. Waste Management Scheme Implemented in Jamaras

DISCUSSION

The main finding of this community engagement program is the emergence of a stable, community–driven circular system that reshapes daily waste routines in a dense urban settlement. The system strengthens household practices, deepens environmental awareness, and supports micro–economic activities (Nogueira et al., 2024; Tàbara et al., 2020; Saiu et al., 2025). The finding also shows rapid adaptation when solutions align with local realities. Community ownership increases, technical confidence improves, and acceptance of decentralized waste processing grows (Subri et al., 2025; Afnan et al., 2025; Leknoi et al., 2024). Evidence from various Indonesian cases supports this behavioral pattern. Studies in Bogor demonstrate that BSF reduces organic waste up to 86% and works effectively in compact urban environments, but adoption requires clear routines and community readiness (Mulyanti et al., 2025). Programs in Ngadilegi Utara show that participation increases when residents join FGD, receive tools, and see BSF as a simple household-scale solution (Choerunnisa et al., 2024). Similar trends appear in Pondok Pesantren Asy-Syifa Muhammadiyah, where residents accept BSF after recognizing economic benefits and the reduction of open burning (Himarosa et al., 2023). Work in Getasan District confirms that social acceptance is stronger when demonstrations, mentoring, and scenario models help residents visualize waste reduction impacts. Findings from Wonorejo Village also show strong understanding of BSF benefits but highlight the need for continued technical guidance to maintain motivation (Melati et al., 2025).

Community-based waste models in Tangerang City further emphasize that empowerment, training, and role-sharing determine long-term success more than technology itself (Asropi et al., 2023). Likewise, the Polaman Village initiative demonstrates that BSF becomes sustainable when supported by local collaboration, waste bank structures, and shared monitoring systems (Sumardiono et al., 2024). A broader review of BSF physiology and nutrient utilization also shows that while BSF can process many waste types efficiently, social factors determine whether community systems remain consistent and productive (Seyedalmoosavi et al., 2022). Compared with these previous studies, the Jamaras program contributes by demonstrating that behavioral and organizational change, not biological metrics, becomes the core outcome. The collective learning process, role distribution, improvisation in limited space, and community-level decision making create a functional circular system in informal urban settings. The experience confirms that simple biological systems such as BSF cultivation and household composting can thrive when embedded in a socially supportive environment with shared responsibilities, visible short-term benefits, and strong motivation.

The differences between the present finding and earlier research appear in four practical dimensions. First, environmental conditions. Many technical studies relied on controlled substrates, moisture, and temperature, producing stable performance outputs. Lalander et al. (2015) and Diener et al. (2011) used laboratory settings, while Purkayastha and Sarkar (2023) demonstrated how BSF performance shifts under managed humidity and thermal ranges. Jamaras operates in fluctuating conditions, with variable waste quality and inconsistent weather. Residents adjust feeding rhythm, moisture, and sorting practices, a behavioral adaptation rarely emphasized in controlled experiments. Similar adaptive constraints are recorded in Tangerang's BSF program, which struggled with practical field inconsistencies (Asropi et al., 2023), and in Depok where environmental instability influenced sustainability metrics (Zulkifli et al., 2025). Second, scale and governance. Earlier community-based initiatives such as Septiariva et al. (2024) and Mukti et al. (2021) relied on formal waste-bank structures or administrative backing. Jamaras runs on an informal, women-led collective with minimal institutional support. The leadership of Watesa centers on social trust, routine care work, and shared responsibility. This governance form reflects patterns noted in Uganda's BSF-SDG model, where grassroots coordination drives participation more effectively than formal bureaucracy (Kasima et al., 2025). Such socially anchored systems differ from structured schemes documented in larger village-scale programs. Third, value pathways. Earlier studies emphasized specialized downstream uses such as germination media, frass valorization, and chitin extraction. González-Lara et al. (2024; 2025) and oil-palm biomass research by Bajra et al. (2023) highlighted industrial optimization. Jamaras instead prioritizes daily utilities: soil media for urban farming, feed for catfish and poultry, and simple compost for household gardens. These low-tech pathways align with community needs and mirror the usability focus observed in Depok's bioconversion program, where waste-derived products support basic household functions (Zulkifli et al., 2025). The simplicity increases acceptance even without high-value processing. Fourth, learning dynamics. Technical literature frequently focused on physicochemical parameters or larval biology, Guo et al. (2012), Sukmawati et al. (2023), and several BSF performance papers (e.g., Jayanegara et al., 2024) concentrated on nutrient flows, feed conversion, or microbial characteristics. Jamaras shows a different trajectory: residents gain skills through repetition, peer tutoring, and observation. Waste handling evolves into a shared routine rather than a technical assignment. Similar participatory learning patterns are noted in community-empowerment studies, where practice-based understanding strengthens long-term habit formation (Nogueira et al., 2024; Tàbara et al., 2020; Saiu et al., 2025; Subri et al., 2025; Afnan et al., 2025; Leknoi et al., 2024).

These differences show that decentralized waste programs succeed not only because of technology but because of social architecture. Trust networks, informal leadership, peer influence, and routine interactions function as enabling elements. Communities adopt new habits after seeing concrete outcomes such as feed, compost, and healthier plants. Visible outputs reinforce behavior, a pattern also reported in school-based BSF programs where hands-on results increase motivation (Walter et al., 2020). Household-scale bioconversion shows similar effects, with residents repeating the process when reductions in waste volume and larval biomass are clearly observed (Ichwan et al., 2021). The implications appear across multiple levels. At the community level, environmental agency strengthens because residents witness that simple actions, sorting waste, feeding larvae, maintaining containers, generate direct value. This aligns with education-based sustainability programs that show higher ecological awareness after practical BSF activities (Setiawan et al., 2025). Peer influence also plays a role; behavioral studies show that subjective norms and perceived control shape long-term waste-sorting habits (Hu et al., 2021). Women-led groups further support continuity. Their consistency, communication style, and relational ties stabilize routines, similar to findings that environmental literacy programs rely on social cohesion to sustain adoption (Syahmani et al., 2021).

At the city scale, decentralized systems reduce transport burdens, ease landfill pressure, and create small circular flows. These outcomes reflect broader evidence that awareness, convenience, and local participation drive sustainable waste practices (Masud et al., 2021). The Jamaras model also illustrates how simple biological processing complements municipal strategies by producing distributed environmental benefits without major infrastructure, consistent with circular principles highlighted in studies of community-based waste innovation (Papamichael et al., 2022; Kasima et al., 2025; Farley et al., 2019). These dynamics are strengthened by participatory routines, shared responsibility, and everyday visible improvements across neighborhoods. Overall, this case reinforces earlier arguments by Septiariva et al. (2021) and Mukti et al. (2021) that community empowerment is a central pillar of sustainable waste management in Indonesia, while adding evidence that behavioral reinforcement, informal leadership, and visible outputs are decisive factors often overlooked.

The findings in Table 4 show that environmental education becomes stronger when tied to direct experience. Residents learn through tactile involvement, handling substrates, observing larval growth, checking compost maturity, adjusting feeding schedules. This pattern aligns with household-scale BSF trials that demonstrate improved understanding through repeated practical engagement (Mahmood et al., 2021). VR-based waste-sorting education also confirms that mastery experiences increase self-efficacy and pro-environmental intention (Stenberdt & Makransky, 2023). Community BSF initiatives in Ghana report similar effects, where visible outputs reinforce learning and strengthen acceptance (Anokye et al., 2025). These observations support arguments that experiential learning surpasses abstract training and should be embedded in community programs (Nogueira et al., 2024; Tàbara et al., 2020; Saiu et al., 2025; Subri et al., 2025; Afnan et al., 2025; Leknoi et al., 2024). Several limitations remain. The community depends on a small core team with limited time and financial capacity, creating vulnerability when participation fluctuates. Monitoring tools are basic, making daily variations difficult to track, similar to constraints identified in studies of BSF systems requiring structured environmental measurements (Salam et al., 2022; Ddiba et al., 2020). Skill differences among households influence stability, echoing household-waste challenges in Zimbabwe where awareness, time, and segregation practices vary widely (Dlamini & Zikhali, 2024; Rehman et al., 2023). Infrastructure remains simple, limiting scalability. Seasonal temperature and moisture shifts affect operation rhythm, consistent with evidence that environmental conditions shape larval performance and bioconversion efficiency (Salam et al., 2022; Wright et al., 2019). Absence of formal market channels for larvae and compost restricts economic potential, a barrier also seen in early circular systems in low-income contexts (Anokye, 2025). These constraints mirror typical challenges in informal settlements and must be considered in replication efforts.

Despite these constraints, the findings offer a grounded view of how circular systems function inside real community life. Technological simplicity becomes a strength when aligned with social cohesion and adaptive learning. The mechanisms observed in Jamaras reflect broader insights from circular-economy transitions in cities, where user engagement and small-loop resource cycles play central roles (Moslinger et al., 2023). The case reinforces earlier work showing the importance of empowerment and localized ownership in Indonesian waste-management programs (Septiariva et al., 2021; Mukti et al., 2021; Siegrist et al., 2023). Broader regional studies also show that improved governance and community participation enhance environmental and public-health outcomes, especially in the Global South (Abubakar et al., 2022). Future studies may explore stronger motivation strategies at household level, simple digital monitoring tools, and low-cost preprocessing methods to reduce daily workload. Research can test micro-enterprise models using larvae, frass, or gardening products to strengthen economic incentives. Further work may analyze youth engagement, seasonal adaptation routines, and peer-to-peer learning, mirroring evidence that experiential or immersive learning environments shape long-term environmental behavior (Stenberdt & Makransky, 2023). Trials on space optimization, odor control, and safe handling would refine operations. Collaboration with schools, microfinance units, urban farmers, and local universities may increase resilience and ensure technical continuity through incremental, context-specific, biodegradable innovations.

Table 4. Finding from This Study

Comparison Aspect	Findings
Daily processing capacity	51.7 kg/day; 53 households
Organic waste proportion	>60% dominant
Main treatment method	BSF + simple composting
Infrastructure condition	Semi-structured BSF system; facility upgrades implemented
Community involvement	High; led by women's group (Watesa)
Primary outputs	Maggots, compost, liquid fertilizer, fish/poultry feed
Waste reduction	8.37 tons/year
CH_4 reduction potential	0.28 tons CH_4/year
Economic benefits	Fish/poultry feed + vegetable production
Main constraints	Limited space; basic equipment
Model strengths	Integrated circular economy (BSF–compost–feed–agriculture)
Unique features	Hybrid BSF + composting + used cooking oil turned into soap
Replication potential	Very high for dense urban settlements
Reference	This article (Jamaras)

CONCLUSION

The community service initiative implemented by LPPM ITB in RW 02 Jamaras has significantly enhanced the organic waste management system by promoting a decentralized, circular economy approach centered around BSF bioconversion. Through coordinated socialization, infrastructural upgrades, and community empowerment, particularly among the Watesa women's group, waste processing capacity has improved, enabling the community to process approximately 8.37 tons of organic waste annually. This effort contributes to an estimated reduction of 0.28 metric tons of methane emissions per year, demonstrating both environmental and climate mitigation benefits. Laboratory analysis of waste characteristics confirmed high moisture content (64.11%) and volatile matter (78.94%) in the organic waste, reinforcing its suitability for biological treatment. The integration of BSF cultivation, composting, and the reuse of outputs (e.g., as fish feed, poultry feed, and organic fertilizer) exemplifies a functioning circular economy model that not only diverts waste from overburdened landfills but also generates tangible economic value for the community. Despite infrastructural limitations and manual labor challenges, the program offers a replicable and scalable model for urban waste management in densely populated, infrastructure-constrained environments. Strengthening this model through policy support and technological investment could amplify its impact across similar urban contexts in Indonesia and beyond.

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AUTHOR CONTRIBUTION STATEMENT

MC conceived the study design, supervised field implementation, and provided overall project coordination. AS coordinated community engagement activities and contributed to the development of the BSF and composting infrastructure. AN carried out waste sampling, laboratory analysis, and data processing. NR supported field surveys, documentation, and preparation of community training materials. RH contributed to data interpretation, graphical visualization, and manuscript structuring. WP performed analysis of waste diversion and greenhouse gas reduction, contributed to the conceptualization of the circular economy framework, and led the manuscript writing and revision, ensuring methodological clarity, integrating multidisciplinary insights, and strengthening the overall scientific narrative through collaboratively driven, iterative, contextually grounded, integrative verification processes supporting scalability, community-responsive adaptation, and ongoing refinement.

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