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Empowering KWT Puspitasari through Maggot Utilization for Organic Waste Reduction in Semarang, Indonesia

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Abstract. Household organic waste has become an increasing problem in urban areas due to population growth and changing consumption patterns. Improperly managed organic waste may cause environmental and public health impacts. This community service program aimed to enhance the capacity of *Kelompok Wanita Tani* (KWT) Puspitasari in managing household organic waste through the cultivation of Black Soldier Fly (BSF) larvae. The method applied a participatory approach consisting of training sessions, demonstrations, hands-on practice, and mentoring, evaluated using a pretest–posttest design. The results indicated a significant improvement in participants' knowledge, with the mean score increasing from 61.47 to 83.24 and the Wilcoxon test showing $p = 0.001$. In addition to cognitive improvement, participants demonstrated practical competence and commitment to continue maggot cultivation independently. The findings confirm that BSF cultivation represents an innovative, sustainable, and economically promising solution for community-based organic waste management.

Keywords: community service; organic waste management; black soldier fly (BSF); women empowerment; urban agriculture

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INTRODUCTION

Waste remains a persistent problem, particularly in urban areas, where it is often perceived as having no value or benefit. Waste originates from human activities and can become an environmental burden if not properly managed. According to the Indonesian National Standard (SNI, 1990), waste is defined as solid material consisting of organic and inorganic substances that are no longer useful. Nevertheless, such waste must still be managed appropriately to prevent environmental hazards. In general, waste is classified into two categories: organic waste (wet waste) and inorganic waste (dry waste) (Blanar & Prada, 2020; Liang et al., 2025).

Organic waste refers to biodegradable material derived from living organisms that can decompose naturally. Household waste is defined as solid waste generated from daily domestic activities, excluding specific waste and human excreta. In developing countries, organic waste constitutes the largest proportion of household waste, ranging from 42% to 80.2% of total waste generation. Household organic waste commonly includes kitchen waste, leftover food, fruit peels, and plant residues that are easily decomposed (Mzhr et al., 2020; Prameselly et al., 2024).

Population growth and increasing consumption patterns have contributed to the rise in both the quantity and diversity of waste generated in urban environments. Urban areas face complex waste management challenges due to diverse lifestyles and consumption behaviors. Therefore, appropriate waste management strategies are required to minimize environmental risks. Indonesian Law No. 18 of 2008 stipulates that waste management can be implemented through

the 3R approach: Reuse, Reduce, and Recycle. In recent years, however, waste management practices have evolved toward more innovative methods. One such innovation involves the utilization of Black Soldier Fly (BSF) larvae, commonly known as maggots, for organic waste processing.

The decomposition of organic material through biological agents has become an innovative strategy in household organic waste management. The utilization of Black Soldier Fly (*Hermetia illucens*) larvae offers a practical alternative for managing organic waste. BSF larvae not only accelerate the decomposition process but also produce high-protein biomass suitable as animal feed. In addition, larval residue can be utilized as compost, while leachate can function as liquid fertilizer. Due to these benefits, BSF-based waste management has become increasingly popular as an environmentally friendly and practical solution that supports ecological and economic resource recovery. Black Soldier Fly insects are commonly found in tropical and subtropical regions. They possess short life cycles and high adaptability, and organic materials serve as their primary food source. For this reason, BSF larvae represent an innovative, practical, and ecological method for organic waste treatment (Gerostamoulos & Schumann, 2022; Wallman & Archer, 2020).

Kelompok Wanita Tani (KWT) Puspitasari, located in Sampangan Village, Gajahmungkur District, Semarang City, Indonesia is a community-based women's farming group engaged in vegetable and fruit cultivation. These activities generate substantial amounts of organic waste, particularly vegetable and plant residues. In addition to waste generated from agricultural activities, the group also processes household organic waste collected from surrounding residents, creating the potential for sustainable waste management within the community. The harvested maggots also have the potential to serve as alternative feed for fish cultivation, which constitutes a future development plan of the group (Abajue & Ewuim, 2020; Akhmaddhian et al., 2021).

However, several challenges persist. Limited urban land availability creates constraints in managing waste within city environments, often resulting in temporary accumulation before transportation to distant final disposal sites. Furthermore, insufficient community knowledge and limited technical skills in selecting appropriate waste processing technologies hinder effective waste reduction efforts. These conditions form the foundation of this community service initiative.

The problems faced by the partner community can therefore be formulated as follows: (1) the abundance of household organic waste in urban areas; (2) limited knowledge and skills in selecting and applying appropriate waste processing technologies that prevent secondary waste generation; and (3) minimal utilization of maggots in organic waste management due to negative perceptions and the belief that maggots are dirty.

Based on these challenges, the objectives of this community service activity are: (1) to enhance household organic waste management through the cultivation of Black Soldier Fly larvae; (2) to reduce the volume of household organic waste in Sampangan Village; (3) to transform community perceptions regarding maggots by demonstrating their effectiveness and environmental benefits; (4) to improve the knowledge and practical skills of KWT Puspitasari members in managing organic waste through BSF larvae cultivation; (5) to provide mentoring support to ensure sustainable implementation; and (6) to facilitate the provision of necessary infrastructure and technical assistance for maggot cultivation.

METHODS

The community service program employed a structured participatory approach designed to enhance the capacity of Kelompok Wanita Tani (KWT) Puspitasari in managing household organic waste through the cultivation of Black Soldier Fly (BSF) larvae. The method was formulated to ensure that the objectives of improving knowledge and skills, reducing organic waste volume, and transforming community perceptions toward maggot utilization could be systematically achieved. The program was implemented through four interconnected phases: planning, organizing, implementation, and evaluation.

The planning phase began with a preliminary field assessment to identify the specific challenges faced by the partner community and to examine the existing potential for integrating BSF-based waste management into ongoing urban farming activities. Discussions were conducted with members of KWT Puspitasari to understand current waste handling practices, limitations in infrastructure, and levels of knowledge regarding organic waste processing. Based on this needs assessment, a detailed activity plan was developed, including the preparation of training

materials, technical guidelines for BSF cultivation, and evaluation instruments. Coordination with local stakeholders was carried out to ensure institutional support and smooth program implementation.

During the organizing phase, all necessary materials and equipment were prepared to support the training and demonstration activities. Facilities for BSF cultivation were arranged, including rearing containers, egg-hatching media, biopond boxes, cages, thermometers, hygrometers, and organic waste storage units. Educational materials were compiled from scientific references covering waste classification, the 3R framework, the life cycle of *Hermetia illucens*, feeding management, environmental control, and harvesting procedures. Pretest and posttest instruments were also prepared to measure participants' knowledge improvement quantitatively. This preparation stage ensured that both theoretical and practical components of the training were delivered effectively.

The implementation phase consisted of lectures, interactive discussions, question-and-answer sessions, demonstrations, hands-on practice, and mentoring. Theoretical sessions introduced participants to the principles of household waste management and emphasized the importance of reducing organic waste at the source. Participants received explanations regarding the biological characteristics of BSF, environmental requirements for cultivation, substrate preparation, feeding frequency, temperature and humidity control, and harvesting techniques. Following the theoretical explanation, a live demonstration was conducted to illustrate each stage of BSF cultivation, including breeding preparation, egg incubation, larval growth management, and waste bioconversion processes. Participants were encouraged to observe the life cycle stages directly and to interact with the cultivation equipment to strengthen practical understanding.

Hands-on practice constituted an essential component of the activity. Participants were guided in sorting organic waste, preparing feeding substrates, placing larvae in rearing containers, and monitoring environmental conditions. Continuous mentoring was provided throughout the activity to ensure proper technique and to build participants' confidence in independently managing the system. The participatory approach was intended to foster active engagement and sustainable adoption of the technology beyond the training session.

Evaluation and monitoring were conducted to measure the level of program success. The primary indicator of achievement was knowledge improvement, measured through a pretest–posttest design. Participants completed a pretest before the training to assess baseline understanding of organic waste management and BSF cultivation. After the completion of the training and practical activities, the same instrument was administered as a posttest. Descriptive statistical analysis was performed to compare mean scores, minimum and maximum values, median, mode, and standard deviation between the two stages. Because the data were not normally distributed, the Wilcoxon signed-rank test was applied to determine whether the difference between pretest and posttest scores was statistically significant at a significance level of 0.05.

In addition to quantitative measurement, qualitative observations were conducted to assess participant engagement and practical competence. Indicators included active participation during discussions, accuracy in demonstrating cultivation procedures, correct use of equipment, and expressed commitment to continue implementing BSF-based waste management. Program success was defined by a statistically significant increase in knowledge scores, observable practical competence among participants, and community commitment to sustain organic waste reduction practices after the completion of the activity. Through this comprehensive method, the program aimed not only to transfer knowledge but also to promote sustainable behavioral change and strengthen community-based environmental management capacity.

RESULTS AND DISCUSSION

Implementation of Activities to Achieve Objectives

The activity was conducted on July 7, 2024, at the RW 03 Community Hall in Sampangan Village. A total of 17 members of KWT Puspitasari participated in the program. The majority of participants were women over 40 years old, reflecting the demographic structure of the farming group. Despite age differences, participants demonstrated high enthusiasm and active engagement throughout the training.

The activity began with theoretical sessions focusing on the fundamentals of waste classification, the urgency of urban waste management, and the introduction of BSF larvae as a biological agent for organic waste conversion.

The trainers explained the increasing complexity of urban waste problems and emphasized the importance of decentralized waste reduction strategies. The 3R framework (Reduce, Reuse, Recycle) was introduced as the regulatory foundation, followed by an explanation of innovative approaches such as bioconversion using BSF larvae.

Figure 1. Documentation of Community Service Activities

The second stage involved practical demonstrations. As documented in Figure 1, participants were introduced to the life cycle of BSF, including eggs, larvae, prepupae, pupae, and adult flies. Demonstrations included the preparation of breeding cages, egg hatching procedures, substrate preparation, larval feeding management, temperature and humidity control, and harvesting techniques.

Participants directly observed maggot cultivation media and equipment, as shown in Figure 2. The demonstration aimed to eliminate misconceptions that maggots are inherently dirty or harmful. Trainers emphasized that BSF larvae are not disease vectors and are safe when cultivated in controlled environments.

Figure 2. Demonstration of Maggot Condition

Hands-on practice followed the demonstration. Participants practiced sorting organic waste, preparing feeding substrates, and managing larval containers. Continuous mentoring ensured that each participant understood operational steps and environmental control requirements. This participatory approach was essential to achieving behavioral change rather than mere knowledge transfer.

Indicators of Goal Achievement

Program success was evaluated using both quantitative and qualitative indicators.

Quantitative Indicator: Knowledge Improvement

The primary quantitative indicator was the improvement in participants' knowledge levels, measured using a pretest–posttest design. The pretest assessed baseline knowledge regarding organic waste management and BSF cultivation prior to training. The posttest measured knowledge after the intervention.

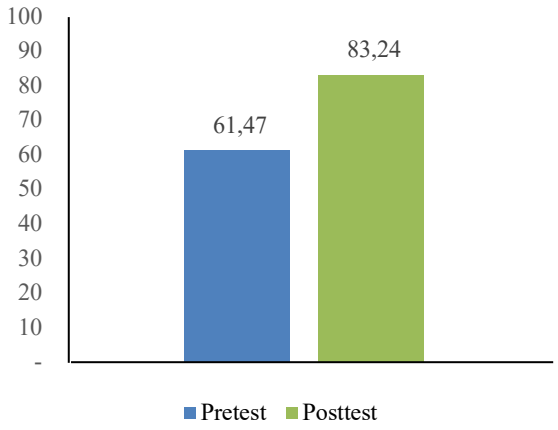

Figure 3. Pre-test and Post-test Scores

The results of the pretest and posttest analysis are presented in **Figure 3** and **Figure 4.**

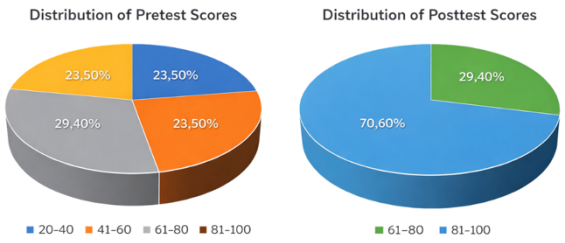

Figure 4. Distribution of Pretest and Posttest Scores

The descriptive statistical results are summarized in Table 1.

Table 1. The Descriptive Statistical Results

Indicator	Pretest	Posttest
Mean	61.47	83.24
Minimum	35	70
Maximum	90	95
Median	70	85
Mode	45	85
Standard Deviation	20.292	7.085

The average score increased from 61.47 to 83.24, indicating a substantial improvement in knowledge. The minimum score increased significantly from 35 to 70, suggesting that participants with initially low understanding achieved meaningful improvement. The decrease in standard deviation from 20.292 to 7.085 indicates greater score homogeneity during the posttest. This suggests that knowledge gains were not limited to high-performing participants but were distributed relatively evenly across the group.

Because the data were not normally distributed, the Wilcoxon signed-rank test was used to examine whether the difference between pretest and posttest scores was statistically significant. The results are summarized in Table 2.

Table 2. Wilcoxon Signed-Rank Test Results

Variable	Pretest vs Posttest
Positive Ranks	15
Negative Ranks	0
Ties	2
p-value	0.001
Conclusion	Significant Difference

The p-value of 0.001 ($p < 0.05$) indicates a statistically significant difference between pretest and posttest scores. Fifteen participants showed improvement, while two participants had stable scores. No participant experienced a decrease in score. This statistical evidence confirms that the training and mentoring effectively enhanced participants' knowledge.

Qualitative Indicators

Qualitative indicators observed during the implementation of the community service activity revealed meaningful behavioral and attitudinal changes among participants. Active participation during discussions reflected an increasing level of environmental awareness and engagement in household waste management practices. Participants were able to explain the life cycle stages of Black Soldier Fly (BSF) larvae, including egg incubation, larval feeding phases, and harvesting procedures, indicating improved conceptual understanding of biological waste conversion processes. Such comprehension is essential because environmental factors, substrate conditions, and temperature control significantly influence larval development and productivity (Mzhr et al., 2020; Meiramkulova et al., 2022). The ability to correctly demonstrate substrate preparation and feeding management further indicated the acquisition of practical skills necessary for sustainable implementation. Proper management of environmental conditions, including humidity and organic substrate consistency, showed that participants understood the biological requirements of *Hermetia illucens*, which are crucial for optimal growth and waste reduction efficiency (Oemar et al., 2023; Wuertz et al., 2022).

Beyond technical competence, a notable attitudinal shift was observed. Initial stigma associating maggots with dirt and decay gradually transformed into recognition of their ecological and economic value. Similar findings in waste management innovation studies suggest that community acceptance is a critical factor in achieving sustainable environmental transformation (Akhmaddhian et al., 2021; Liu et al., 2021). Participants also expressed commitment to continue maggot cultivation independently after the completion of the program, demonstrating ownership and long-term motivation. This aligns with research emphasizing that successful waste utilization initiatives require not only technological transfer but also social adaptation and community-driven sustainability (Rimantho et al., 2022; Noor et al., 2025). Therefore, qualitative outcomes confirm that the program generated cognitive improvement, strengthened practical capability, and fostered positive behavioral change toward environmentally responsible waste management practices.

Strengths of the Program

The success of this community service initiative was supported by several contextual and strategic strengths. First, the program was closely aligned with the existing activities of KWT Puspitasari as an urban farming group that routinely manages plant residues and household organic waste. Such contextual compatibility reduced resistance to innovation and facilitated adaptive integration rather than requiring a

complete behavioral shift. Studies on sustainable waste governance emphasize that policy and technological interventions are more effective when they are embedded within local socio-environmental practices (Akhmaddhian et al., 2021; Anggraini et al., 2025). Second, the participatory learning approach strengthened engagement and collective ownership. Demonstrations and hands-on practice enhanced experiential understanding, consistent with evidence that community-based waste utilization initiatives achieve higher sustainability when knowledge transfer is combined with active involvement (Liu et al., 2021; Rimantho et al., 2022). Third, the provision of initial equipment and maggot stock minimized financial barriers, enabling immediate application. Finally, the integration of environmental and economic value added strategic relevance. The potential use of maggot biomass as alternative fish feed aligns with research demonstrating the nutritional and commercial benefits of insect-based feed in aquaculture and livestock systems (Ogunji et al., 2021; Wuertz et al., 2022), thereby supporting income diversification and local food resilience.

Weaknesses and Limitations

Despite its demonstrated strengths, several limitations emerged during implementation. Participation was limited to active members of KWT Puspitasari, which restricted the broader diffusion of knowledge across the surrounding community. Waste management transformation requires collective behavioral change and supportive governance structures; without wider engagement, the overall reduction of household organic waste may remain localized (Akhmaddhian et al., 2021; Liu et al., 2021). In addition, urban land constraints present structural challenges for scaling up production. Although BSF cultivation is more space-efficient than conventional composting systems, expansion requires careful spatial planning, infrastructure adjustment, and integration into municipal waste strategies (Anggraini et al., 2025; Rimantho et al., 2022). Limited space may also restrict the installation of breeding cages and waste storage units, thereby constraining production volume.

Another limitation relates to social perception and operational sustainability. Negative stigma toward maggots may persist beyond trained participants, potentially affecting market acceptance and community adoption. Research on environmental innovation emphasizes that technological feasibility alone does not guarantee social acceptance; awareness-building and education remain essential (Liu et al., 2021; Mooijman et al., 2021). Furthermore, production sustainability depends heavily on consistent organic waste supply and proper environmental management. Temperature, humidity, and substrate quality significantly influence larval development, and irregular feeding or improper conditions may disrupt the life cycle and reduce productivity (Mzhr et al., 2020; Oemar et al., 2023). Continuous mentoring and monitoring are therefore necessary to maintain stable and efficient maggot cultivation systems.

Level of Implementation Difficulty

The level of implementation difficulty in Black Soldier Fly (BSF) cultivation can be categorized as moderate when applied at the community level. Basic operational procedures, such as organic waste sorting, substrate preparation, and larval feeding, are relatively simple and can be mastered through short-term training. However, maintaining optimal environmental conditions remains a critical technical component. BSF larvae develop efficiently within specific temperature and humidity ranges, and fluctuations may affect growth rate and survival (Mzhr et al., 2020; Meiramkulova et al., 2022). Monitoring environmental parameters therefore requires consistency and basic technical understanding. Participants initially expressed concerns regarding egg incubation and adult fly breeding management, as these stages demand greater precision compared to routine feeding practices. The reproductive phase is particularly sensitive to environmental conditions and substrate quality, which directly influence larval yield and waste conversion efficiency (Oemar et al., 2023; Wuertz et al., 2022).

In addition to biological management, hygiene control presents another practical challenge. Although BSF larvae significantly reduce odor and accelerate organic waste decomposition compared to unmanaged waste systems, improper substrate management may still generate unpleasant smells or contamination risks (Blanar & Prada, 2020; Rimantho et al., 2022). Regular cleaning, appropriate waste segregation, and adequate aeration are therefore necessary to maintain environmental quality. Despite these challenges, the overall level of difficulty remains manageable when supported by structured training, continuous mentoring, and initial supervision. Community-based implementation studies indicate that technical barriers can be

minimized when knowledge transfer is combined with hands-on practice and institutional support (Liu et al., 2021), thereby enabling sustainable adoption at the local level.

Opportunities for Future Development

The program presents substantial opportunities for future development, particularly in scaling up production and strengthening economic value chains. Expanding Black Soldier Fly (BSF) cultivation could enable KWT Puspitasari to produce commercial dried maggot feed or maggot flour, thereby generating additional income streams. Research has demonstrated that insect-based feed derived from maggot larvae provides high nutritional value and can effectively substitute conventional fishmeal in aquaculture and poultry production (Ogunji et al., 2021; Wuertz et al., 2022). Moreover, dietary replacement with fly larvae has been shown to enhance edible yield and nutritional quality in aquaculture commodities (Liang et al., 2025). These findings indicate strong market potential for maggot-based feed products. In parallel, the production of kasgot (maggot residue) as organic fertilizer aligns with urban farming practices and supports circular resource recovery, reducing dependency on external agricultural inputs (Prameselly et al., 2024; Noor et al., 2025).

Institutional collaboration also offers strategic development pathways. Integrating BSF-based waste management into municipal waste reduction policies could strengthen neighborhood-level sustainability frameworks (Anggraini et al., 2025; Rimantho et al., 2022). Partnerships with environmental agencies would facilitate regulatory support and broader community adoption. Furthermore, incorporation into school-based environmental education programs may promote early awareness and long-term behavioral change toward sustainable waste practices (Humphreys et al., 2022). Replication across other urban farming groups could amplify environmental impact and create decentralized waste reduction networks. Such expansion aligns with lessons from community-driven waste utilization initiatives that emphasize scalability, policy integration, and social enterprise development for long-term sustainability (Liu et al., 2021).

Alignment with Community Conditions

The program demonstrates strong alignment with the socio-environmental conditions of Sampangan Village, which faces typical urban challenges such as household waste accumulation and limited land availability. Urban waste management systems often struggle with space constraints and inefficiencies in collection and disposal processes, necessitating decentralized and community-based solutions (Anggraini et al., 2025; Rimantho et al., 2022). Black Soldier Fly (BSF) cultivation offers contextual suitability because it reduces organic waste volume rapidly while requiring relatively small operational space compared to conventional composting systems. Research indicates that BSF-based waste utilization contributes to sustainable urban waste reduction by transforming food waste into valuable biomass within controlled environments (Oemar et al., 2023; Meiramkulova et al., 2022). Therefore, the integration of BSF cultivation into an urban farming setting addresses both spatial limitations and environmental concerns simultaneously.

The demographic composition of KWT Puspitasari, predominantly women responsible for household management, further strengthens the contextual relevance of the program. Women play central roles in domestic waste generation, sorting, and disposal, positioning them as key actors in household-level environmental transformation (Liu et al., 2021). Community-based environmental initiatives are more sustainable when they empower local actors who directly manage daily waste practices (Akhmaddhian et al., 2021). Moreover, the program's compatibility with existing agricultural activities enhances long-term feasibility. The production of maggot biomass for animal feed and kasgot fertilizer for crops aligns with integrated resource recovery models that support circular urban agriculture (Noor et al., 2025; Wuertz et al., 2022). This synergy between waste reduction and agricultural productivity increases the likelihood of sustained adoption and community resilience.

Assessment of Program Success

The assessment of program success was supported by both quantitative and qualitative evidence. Statistical analysis demonstrated a significant difference between pretest and posttest scores ($p = 0.001$), with the mean increasing from 61.47 to 83.24 and a notable reduction in score dispersion. This improvement indicates not only knowledge acquisition but also greater uniformity of understanding among participants. Community-based environmental interventions are considered effective when measurable learning outcomes are accompanied by

statistically significant change (Rimantho et al., 2022; Liu et al., 2021). The reduction in variability further suggests that knowledge transfer was inclusive rather than limited to a small group of high-performing individuals. From a governance perspective, measurable educational outcomes strengthen the legitimacy and sustainability of waste management initiatives (Akhmaddhian et al., 2021; Anggraini et al., 2025).

Beyond numerical gains, qualitative indicators reinforced the program's effectiveness. Active engagement during discussions, correct demonstration of cultivation procedures, and expressed commitment to continued implementation reflected practical competence and attitudinal transformation. Research emphasizes that sustainable waste utilization programs require behavioral change, community ownership, and integration with local economic practices (Noor et al., 2025; Oemar et al., 2023). The combination of improved technical understanding and willingness to sustain BSF cultivation suggests that the program successfully laid the foundation for long-term organic waste management within KWT Puspitasari. This integrated outcome statistical improvement, skill acquisition, and strengthened commitment aligns with sustainability models that highlight the importance of linking environmental innovation with social adaptation and community resilience (Meiramkulova et al., 2022; Wuertz et al., 2022).

CONCLUSION

The community service program on household organic waste management through Black Soldier Fly (BSF) larvae cultivation at KWT Puspitasari demonstrated measurable and meaningful success. Statistical analysis confirmed a significant improvement in participants' knowledge, reflected in the increase of mean scores from 61.47 to 83.24 and supported by a Wilcoxon test result of $p = 0.001$, alongside reduced score dispersion indicating more uniform understanding. Qualitative observations further revealed enhanced practical competence, active engagement, and strengthened commitment to continue maggot cultivation independently. The program's main strengths lie in its contextual alignment with urban farming activities, its participatory learning approach, and its integration of environmental and economic benefits through potential fish feed and organic fertilizer production. However, limitations were identified, including restricted participant coverage, urban land constraints for scaling up production, persistent social stigma toward maggots in the broader community, and the need for consistent maintenance to sustain production cycles. Despite these challenges, the overall level of implementation difficulty remains manageable with structured training and mentoring. The initiative holds strong potential for further development through production scaling, commercialization of maggot-based products, integration into local waste management policies, educational outreach, and replication in other urban farming communities. Therefore, BSF-based organic waste management presents a viable, sustainable, and community-driven model for urban environmental resilience and socio-economic empowerment.

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