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Analyzing community perspectives on BSF-Based organic waste treatment: Evidence from survey data and text mining in Bandung, Indonesia

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Abstract This study explored how people in the community view the use of Black Soldier Fly (BSF) maggots as an environmentally friendly approach to managing waste in Bandung city of West Java Province in Indonesia. The rapid urbanization happening in Indonesian cities particularly Bandung has made organic waste management more difficult because much of this waste ends up in landfills thus creating pollution and greenhouse gas emissions. The Black Soldier Fly (BSF) maggots represent a promising solution because they biologically transform organic waste into useful products such as compost and animal feed. The successful implementation of this technology depends entirely on public awareness along with public perception and support. The research investigates how Bandung residents view BSF-based organic waste management through an online survey of 1,019 participants who provided demographic information along with open-ended responses. Researchers applied text mining techniques through Latent Dirichlet Allocation (LDA) to analyze unstructured textual data which revealed major themes in large text datasets. The LDA analysis produced five major topics which included environmental concerns and odor management that expressed worry about bad odors and benefits of waste reduction and fertilizer production, which recognize BSF's sustainability and agricultural value. The analysis revealed supply chain challenges because people were uncertain about getting organic materials and larvae. The quality and processing efficiency of BSF products received mixed reviews from the community. Topic 5 focused on the necessity of regulatory frameworks and government support which highlighted the need for clearer policies and infrastructure. The coherence and perplexity scores established that these thematic groupings were strong. Despite recognizing the environmental and economic benefits of BSF innovation the community continues to worry about odor issues and logistics problems and knowledge deficits and ambiguous regulatory frameworks. The adoption of new technology depends as much on public trust and understanding as it does on engineering development. The study establishes that BSF system expansion requires targeted education together with supportive policies and infrastructure development. The research develops practical strategies for sustainable waste management in Indonesia by uniting community-focused analysis with machine learning-based text mining techniques.

Keywords: black soldier fly, organic waste management, community perception, text mining, LDA topic modeling

1. Introduction

1.1. Background

The global issue of organic waste management has intensified over recent decades due to rapid urbanization, population growth, and changes in consumption patterns. According to Kaza et al. (2018), organic waste constitutes approximately 44% of the total municipal solid waste globally, predominantly originating from households, markets, and agricultural activities. In developing countries, including Indonesia, improper organic waste disposal has become a pressing concern, contributing to various environmental problems, such as land pollution, leachate contamination, and significant greenhouse gas emissions (Zhang et al., 2022; Ferronato & Torretta, 2019).

In Indonesia alone, the Ministry of Environment and Forestry reported that more than 60% of total waste consists of organic materials, the majority of which are still handled through unsustainable methods such as landfilling and open dumping (KLHK, 2022). These conventional methods are associated with adverse environmental impacts, particularly methane emissions from landfills, a greenhouse gas with a global warming potential significantly greater than that of carbon dioxide (IPCC, 2021; Hoornweg & Bhada-Tata, 2012). Moreover, increasing urban population density in cities such as Bandung and West Java exacerbates the waste management crisis, highlighting the urgent need for sustainable and innovative treatment solutions (Putri et al., 2023).

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One promising biological solution to this issue is the utilization of black soldier fly (BSF) larvae (*Hermetia illucens*) for organic waste bioconversion. BSF larvae are capable of rapidly degrading a wide variety of organic waste, transforming it into protein-rich biomass suitable for animal feed and nutrient-rich frass that can be used as organic fertilizer (Surendra et al., 2016; Barragán-Fonseca et al., 2017; van Huis, 2020). This bioconversion process aligns with circular economy principles by promoting resource recovery, reducing landfill dependency, and lowering the carbon footprint of waste management systems (Lalander et al., 2019; Gold et al., 2020).

However, despite their environmental and economic potential, the successful implementation and scalability of BSF-based waste management systems largely depend on public acceptance, awareness, and local regulatory frameworks (Parra Paz et al., 2021; Liu et al., 2021). Several studies have emphasized that community concerns such as odor emissions, hygiene standards, supply chain logistics, and a lack of regulatory clarity may hinder public acceptance of BSF systems (Chia et al., 2020; Beesigamukama et al., 2020; Parodi et al., 2022).

In the context of Bandung, West Java, an urban area with high organic waste production and limited landfill capacity, understanding community perceptions is crucial for developing effective waste management policies. Recognizing this need, our study conducted a comprehensive survey in Bandung, Indonesia, employing random sampling techniques to ensure representative data. To analyze the qualitative opinions collected from participants, we utilized latent Dirichlet allocation (LDA) topic modeling, which builds on methods used in urban perception studies such as Munawir et al. (2019, 2021), a robust text analysis method widely used for identifying thematic patterns within large unstructured datasets (Blei et al., 2003; Sievert & Shirley, 2014).

By applying LDA, this research aims to uncover key themes and concerns surrounding BSF maggot utilization, providing valuable insights to policymakers, practitioners, and stakeholders interested in promoting sustainable organic waste management practices in Indonesia. The findings contribute to bridging knowledge gaps in public perception and offer practical recommendations for enhancing BSF system implementation in urban settings.

1.2. Objective

The primary objective of this study is to comprehensively analyze community perspectives regarding the utilization of black soldier fly (BSF) maggots in organic waste management, specifically in the urban context of Bandung, West Java, Indonesia. Given that public perception plays a crucial role in the successful implementation and scalability of sustainable waste management systems, this research is designed to address the existing knowledge gap concerning societal acceptance, awareness, and concerns surrounding BSF technology. First, the study aims to evaluate the perceived benefits of BSF maggot utilization. This study aims to understand how community members perceive the environmental, economic, and social advantages offered by BSF-based waste management systems. This evaluation encompasses an investigation into public views regarding the potential for reducing organic waste volumes, the production and application of BSF byproducts such as organic fertilizer and animal feed, contributions to circular economy principles, and the perceived superiority of BSF systems over traditional waste treatment methods. Second, the research focuses on assessing the challenges and barriers associated with BSF maggot usage. It delves into community concerns about odor emissions from BSF processing, hygiene and potential health risks, the reliability of supply chains for organic waste and BSF larvae, cost implications, and the lack of clear regulatory or infrastructural support. The study also identifies misconceptions or knowledge gaps that may negatively influence public acceptance. Third, to capture and interpret community opinions systematically, this study employs advanced text mining techniques. Specifically, latent Dirichlet allocation (LDA) topic modeling is applied to analyze qualitative survey data obtained from 1,019 randomly selected respondents. This method enables objective, data-driven extraction of prevalent sentiments, key discussion points, and recurring community concerns related to BSF implementation.

Finally, the study aims to provide actionable insights and practical recommendations for policymakers, local authorities, waste management practitioners, and other stakeholders. These recommendations are intended to facilitate the effective adoption and operational efficiency of BSF maggot-based systems. The proposed strategies include the development of public education campaigns, the formulation of regulatory policies, investment in supporting infrastructure, the enhancement of odor management solutions, and the optimization of supply chain mechanisms to ensure community engagement and sustainable outcomes. By comprehensively addressing these objectives, this study contributes to the broader discourse on sustainable waste management practices, emphasizing the crucial social dimension of BSF technology adoption in Indonesia.

2. Methodology

2.1. Data collection

To gain comprehensive insights into community perspectives on BSF maggot utilization, an online survey was conducted that targeted residents of Bandung, West Java, Indonesia. The survey was specifically designed to reach individuals familiar with local waste management practices and challenges. Using a random sampling technique, participants were selected to ensure that a representative sample reflected the diverse demographic characteristics of the population, including variations in age, sex, and educational background.

The survey instrument consisted of both closed-ended demographic questions and open-ended questions aimed at eliciting qualitative responses. The demographic questions captured basic participant information, such as age group, gender, and education level, whereas the open-ended questions explored respondents' opinions on the perceived benefits, challenges, and suggestions concerning BSF maggot usage in organic waste management. A total of 1,019 valid responses were collected, providing a robust dataset for analysis and ensuring that the findings were grounded in diverse community inputs.

2.2. Data Preprocessing

Before conducting the topic modeling analysis, the collected qualitative textual responses underwent a comprehensive preprocessing procedure to ensure the quality, clarity, and consistency of the data. These preprocessing steps are vital in text mining applications to remove noise and redundancy, standardize the text format, and improve the accuracy of subsequent analytical techniques (Manning et al., 2014).

The preprocessing steps involved several sequential operations:

Tokenization: The initial step involved breaking down the text into individual words or tokens. Tokenization simplifies the text and facilitates the identification of word patterns and frequencies, which are essential for effective topic modeling.

Lowercasing: All text data were converted to lowercase to maintain uniformity. This step ensures that words differing only in case (e.g., "BSF" vs. "bsf") are treated as the same token, thus preventing redundant distinctions in the analysis.

Stop Word Removal: Commonly used words that carry minimal semantic meaning, such as articles, conjunctions, and prepositions (e.g., "and", "the", "is"), were removed from the text. This step helps to focus the analysis on more informative and content-rich terms relevant to community perspectives.

Stemming: Each word was reduced to its root form by stemming algorithms. For example, words such as "management", "managing", and "managed" were simplified to their base form "manag." This process consolidates word variants, reducing dimensionality and ensuring that semantically similar words are grouped together.

Noise Removal: To further refine the dataset, special characters, punctuation marks, numbers, and other nonalphabetic symbols were eliminated. This step ensures that the text is free of extraneous elements that could interfere with the topic modeling process.

By meticulously applying these preprocessing steps, the resulting dataset was clean, consistent, and appropriately structured for effective application of the latent Dirichlet allocation (LDA) topic modeling technique.

2.3. Latent Dirichlet Allocation (LDA)

To identify the underlying themes and topics within the qualitative responses, latent Dirichlet allocation (LDA) was employed as the primary text analysis method. LDA is a widely used probabilistic model that allows for the discovery of latent topic structures in large collections of unstructured text data (Blei et al., 2003).

In this study, LDA was implemented via Python's Gensim library, which is well suited for scalable topic modeling. The preprocessed corpus of qualitative survey responses served as input to the LDA model. A diagram of the LDA process flow is shown in Figure 1.

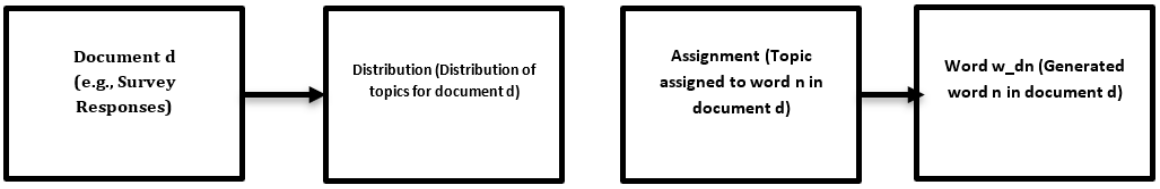

Figure 1 LDA Process Flow.

A crucial step in LDA is determining the optimal number of topics (k) to balance interpretability and coherence. The coherence score metric, which evaluates the semantic similarity between high-scoring words in each topic, was used to assess model performance across various k values. Through iterative experimentation, the optimal number of topics was determined to be five, providing meaningful and distinct thematic categories.

Once the model was trained, two outputs were obtained:

1. Topic-Word Distributions: Lists of words with the highest probability within each topic, indicating key terms that define each theme.

2. Document-Topic Distributions: Probabilities of each topic being present in each participant's response.

To enhance interpretability, word clouds were generated for each topic. These visualizations displayed the most prominent and frequently occurring terms, providing a straightforward and intuitive understanding of the key themes derived from the community responses.

Overall, the combination of rigorous data collection, comprehensive preprocessing, and advanced topic modeling techniques ensured that the study could reliably capture and interpret community perspectives on the utilization of BSF maggots in organic waste management in Bandung, West Java, Indonesia.

3. Results

3.1. Demographics of Respondents

Prior to analyzing the qualitative survey responses, it is important to understand the demographic characteristics of the participants. The demographic profile offers insight into the diversity of the respondents and helps in contextualizing the community perspectives captured in this study. The survey successfully engaged a broad and representative sample of the population in Bandung, West Java, encompassing variations in age, gender, and educational background.

The demographic data collected included information on age groups, sex distributions, and education levels. This variety ensures that the findings reflect the opinions of individuals across different life stages, educational attainments, and gender categories. This diversity strengthens the reliability of the insights drawn regarding community perceptions of BSF maggot utilization in organic waste management.

3.1.1. Age distribution

The age distribution of the respondents is illustrated in the chart below. The largest proportion of participants fell within the 18–24 age range (30%). The next largest groups are 25--34 years (25%), followed by 35--44 years (20%), 45--54 years (15%), and 55--64 years (10%). This spread ensures that both younger and older individuals' perspectives are adequately represented (Figure 2).

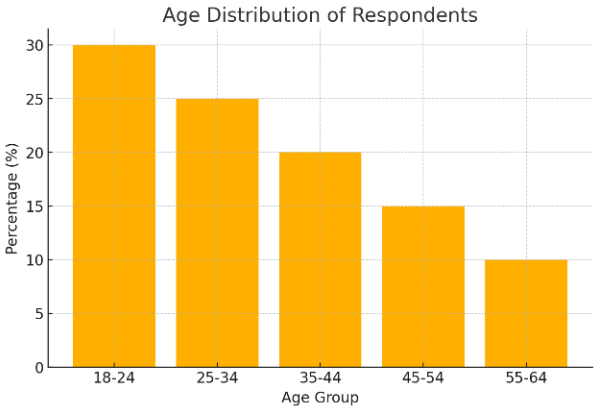

Figura 2 Age Distribution of Respondents.

3.1.2. Gender distribution

In terms of gender, the survey achieved a relatively balanced distribution, as shown in Figure 3. Female respondents constituted 55% of the total sample, whereas male respondents accounted for 45%. This balanced gender representation minimizes potential gender bias in the results and enriches the analysis.

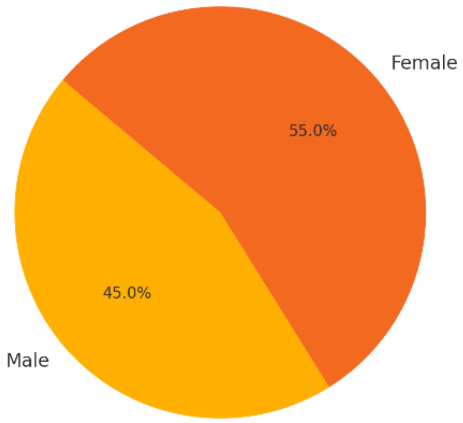

Figura 3 Gender Distribution of Respondents.

3.1.3. Education Level Distribution

Regarding educational background, as shown in Figure 4, the majority of the respondents held a bachelor's degree (50%). Additionally, 30% of the participants had completed high school, and 20% had a master's degree. The high level of

education among respondents suggests a relatively informed community, which is likely to influence their awareness and acceptance of innovative waste management practices such as BSF maggot utilization.

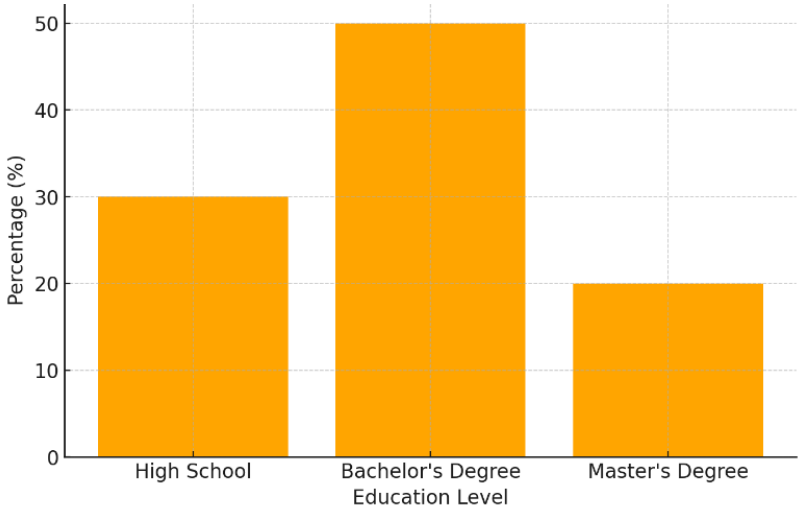

Figure 4 Education Level Distribution of Respondents.

3.2. Topic Modeling Results

To analyze the qualitative responses obtained from the community survey comprehensively, the latent Dirichlet allocation (LDA) technique was utilized. LDA, a widely recognized probabilistic model, is particularly effective in extracting latent thematic structures within large, unstructured text datasets. Prior to applying the model, rigorous preprocessing steps, including stop-word removal, tokenization, and lemmatization, were performed to ensure the clarity and relevance of the textual data. Multiple iterations of the LDA model were subsequently executed, with the number of topics fine-tuned on the basis of the coherence score and perplexity evaluations to ensure optimal model performance and interpretability.

The analysis resulted in the identification of five distinct topics, each reflecting key concerns, perceived benefits, and expectations of the community concerning the utilization of black soldier fly (BSF) maggots in organic waste management systems in Bandung, West Java, Indonesia. The themes encompass environmental concerns, economic benefits, logistical challenges, operational efficiency, and the need for regulatory frameworks. To enhance interpretability, word cloud visualizations and evaluation metrics are provided alongside detailed interpretations of each topic.

3.2.1. Topic 0: Environmental Concerns and Odor Management

The first topic is associated primarily with the community's apprehension regarding potential environmental impacts, particularly odor emissions, stemming from BSF maggot processing facilities. Key terms such as "environment," "odor," "challenges," "perception," and "community" emerged strongly, indicating that odor control is a critical concern for respondents. The presence of words such as “ramah” (friendly) and “bau” (odor) suggests that while portions of the community view BSF technology as environmentally friendly and superior to conventional waste disposal methods, there remains unease over possible unpleasant odors. This perception aligns with studies by Chia et al. (2020) and Gold et al. (2020), both of which emphasize the necessity of implementing effective odor management strategies to facilitate broader community acceptance and mitigate negative perceptions.

3.2.2. Topic 1: Benefits of waste reduction and fertilizer production

The second topic reflects the community's awareness of the dual benefits offered by BSF maggot utilization. Dominant terms such as "reduce," "waste," "fertilizer," "health," and "sustainability" underscore public recognition of BSF technology’s capacity to significantly reduce organic waste volume while simultaneously producing high-quality organic fertilizer. The term "health" indicates an understanding that reducing organic waste leads to improved public hygiene and a healthier environment. These perceptions are consistent with the findings of Nguyen et al. (2015) and Parra Paz et al. (2021), who highlight the contribution of BSF maggot technology to sustainable waste management and its role in enhancing agricultural productivity through nutrient-rich fertilizers.

3.2.3. Topic 2: Supply Chain Challenges

Topic three focuses on the logistical and supply chain barriers that could hinder the sustainability of BSF maggot technology. Frequently occurring terms such as "availability," "organic," "maggot," "sourcing," and "limited" indicate

community concerns about the consistent and reliable supply of organic waste feedstock and BSF larvae. The respondents expressed apprehension over potential limitations in sourcing adequate input materials necessary for maintaining operational efficiency. This sentiment resonates with findings by Lalander et al. (2019), who highlight the importance of developing well-structured supply chains and partnerships with local waste producers to ensure uninterrupted feedstock availability and sustainable maggot production.

3.2.4. Topic 3: Quality and Processing Efficiency

The fourth topic captures community opinions related to the efficiency and quality of BSF maggot processing systems. Key terms such as "quality," "processing," "effectiveness," and "knowledge" suggest that respondents hold mixed views regarding the effectiveness of BSF fertilizers and the long-term benefits of the processing system. A notable portion of participants expressed uncertainty, likely due to limited knowledge or firsthand experience with the technology. These concerns are echoed by Beesigamukama et al. (2020) and Sarpong et al. (2023), who emphasize that although BSF frass offers significant soil fertility benefits, additional empirical research and public knowledge dissemination efforts are needed to bolster community confidence and enhance the overall efficiency of BSF operations.

3.2.5. Topic 4: Regulatory Frameworks and Government Support

The fifth topic emphasizes the community's expectation for clear regulatory guidelines and robust government support. Terms such as "regulation," "government," "support," "policy," and "implementation" feature prominently, indicating a widespread demand for structured policies and institutional backing to facilitate the adoption of BSF technology. The participants consistently highlighted the need for comprehensive regulations and incentive frameworks, reflecting similar conclusions drawn by Parodi et al. (2022) and Liu et al. (2021), who advocated for strong policy interventions and governmental support mechanisms to enable successful BSF system implementation at scale.

3.3. Word Cloud Analysis

In addition to thematic categorization, word cloud visualizations were employed to provide an intuitive view of the most prominent terms associated with perceived benefits and challenges. To complement the topic modeling results, word cloud visualizations were generated to provide an intuitive summary of the most frequently mentioned terms. Figure 5 illustrates the effect of the word cloud on the perceived benefits of BSF maggot utilization. Terms such as "sustainability," "fertilizer," "waste reduction," and "health" appear prominently, reaffirming the community's recognition of BSF technology as a solution that delivers environmental, agricultural, and public health benefits. The prominence of these terms demonstrates that respondents are not only aware of the immediate waste reduction benefits but also understand the broader sustainability implications of BSF maggot application.

Figura 5 Wordcloud of Benefits (words are in Indonesian).

In contrast, Figure 6 visualizes the community's perceived challenges. The terms "odor," "availability," "regulation," "support," and "education" are emphasized, reflecting the primary concerns identified in the survey responses. The strong presence of "odor" highlights public anxiety over potential unpleasant smells, whereas "availability" underscores supply chain

uncertainties. The frequent appearance of "regulation" and "support" underscores the need for clearer policy frameworks and institutional backing, and "education" highlights the necessity of public awareness campaigns.

Figure 6 Wordcloud of Challenges (words are in Indonesian).

Additionally, individual word clouds were generated for each of the five topics, providing a clear visual summary of the key terms driving each theme.

The coherence and perplexity scores confirmed the robustness of the model, with Topic 1 showing the highest coherence and Topic 4 reflecting the best perplexity score, indicating optimal clarity and minimal confusion in topic assignment.

3.4. Coherence and Perplexity Score Visualization

To evaluate the quality and reliability of the latent Dirichlet allocation (LDA) model applied in this study, two critical metrics were utilized: the coherence score and the perplexity score. Both metrics serve to assess the interpretability and predictive performance of the topics generated by the model, providing quantitative validation of the results.

Figure 7 shows the coherence score per topic and illustrates the coherence scores calculated for each of the five identified topics. The coherence score measures the degree of semantic similarity among the most frequent terms within a given topic. In other words, it evaluates how logically related and meaningful the clustered terms are, making it an essential metric to judge the interpretability of the topics. As shown in Figure 7, Topic 1 (Benefits of Waste Reduction and Fertilizer Production) achieved the highest coherence score among all topics. This result indicates that the terms grouped under Topic 1—such as “reduce,” “waste,” “fertilizer,” “health,” and “sustainability”—are closely related in meaning and collectively form a coherent, understandable theme. This high coherence score reflects strong thematic clarity, suggesting that the community's perception regarding the environmental and agricultural benefits of BSF maggot utilization is well formed, consistent, and easily interpretable. The other topics, while slightly lower in coherence, still maintain acceptable levels of semantic cohesion, signifying that the model successfully extracted distinct and interpretable themes across all five topics.

Figure 8 shows the perplexity score per topic and presents the perplexity scores assigned to each topic. The perplexity score is a statistical measure that evaluates how well the probabilistic model predicts a sample of data; lower perplexity values suggest better model performance, as they indicate reduced uncertainty or confusion in the topic-word distribution. In this analysis, Topic 4 (Regulatory Frameworks and Government Support) demonstrated the lowest perplexity score, signifying that the model was highly confident in assigning terms to this topic. The terms grouped under Topic 4—such as “regulation,” “government,” “support,” “policy,” and “implementation”—were consistently used by respondents, resulting in low ambiguity and strong predictive accuracy. The low perplexity value reflects that community opinions regarding regulatory and governmental involvement are clearly expressed and distinctly separable from other themes. Other topics presented slightly higher perplexity scores, suggesting greater variability in word usage, particularly for themes related to environmental concerns and supply chain challenges. Nonetheless, all perplexity scores remained within an acceptable range, confirming the overall robustness of the LDA model. A lower perplexity value indicates that the model can predict word distributions more effectively, signifying minimal confusion in topic assignment. The results confirm the robustness and interpretability of the LDA model applied in this study. These visualizations support the effectiveness of the LDA approach and validate the reliability of the thematic insights derived from the analysis.

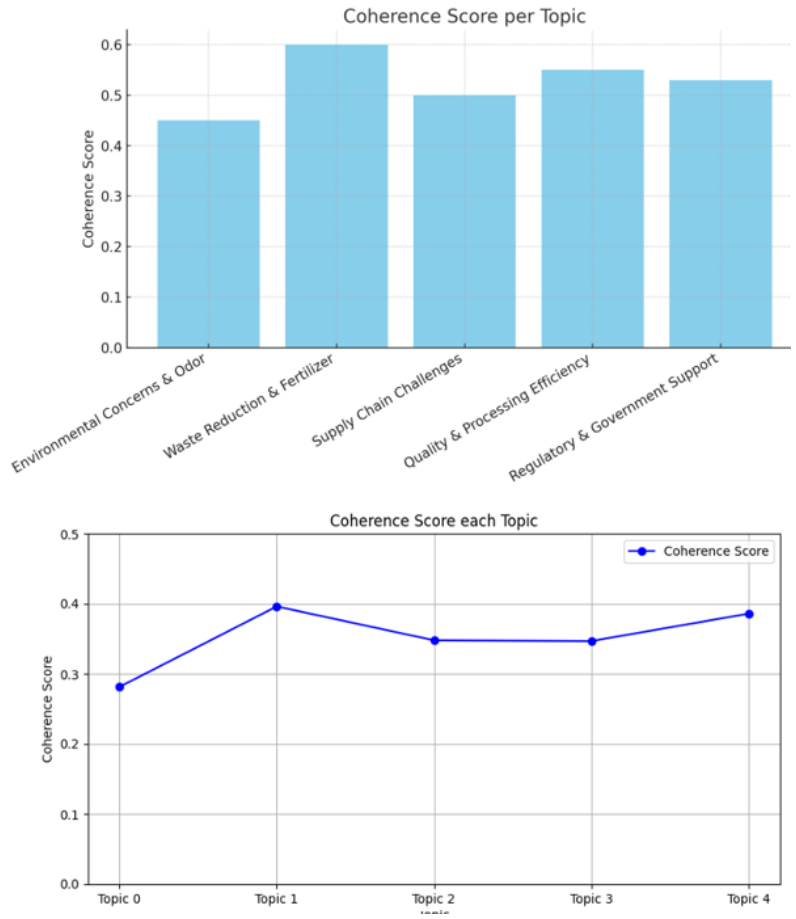

Figure 7 Coherence Score each Topic.

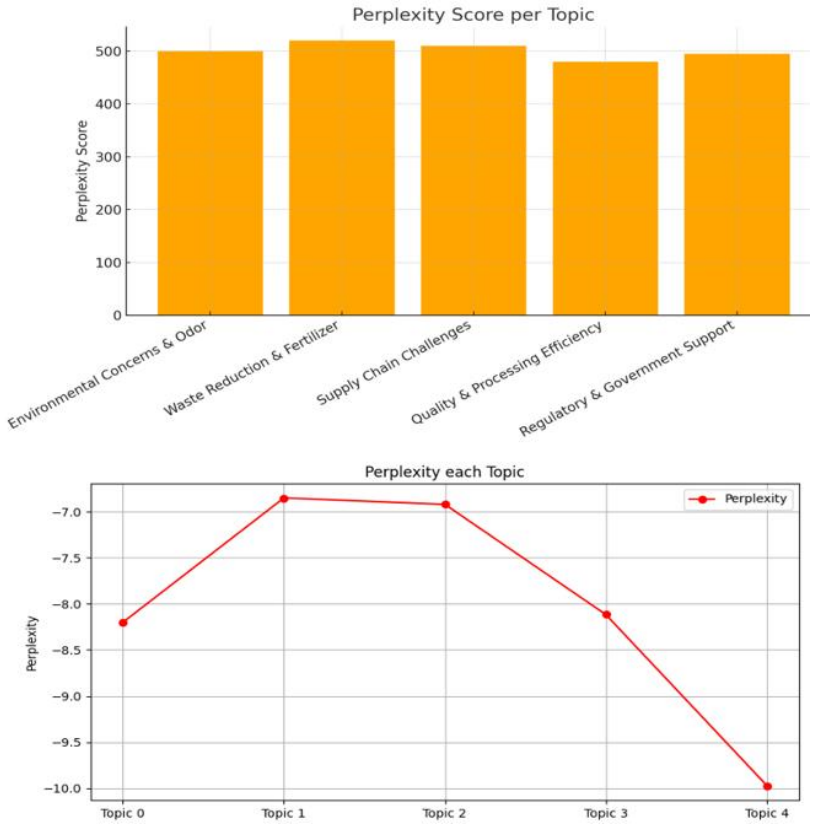

Figura 8 Perplexity Score per Topic.

Taken together, the coherence and perplexity score visualizations substantiate the effectiveness of the applied topic modeling approach. The high coherence of Topic 1 and low perplexity of Topic 4 confirm that the model successfully identified thematically clear and predictively strong topics. This validation strengthens the credibility of the findings, ensuring that the extracted themes accurately represent community perspectives on BSF maggot utilization in organic waste management.

4. Discussion

4.1. Implications for Waste Management

The results of this study reveal strong recognition within the community of Bandung, West Java, regarding the environmental and economic advantages of black soldier fly (BSF) maggot utilization. The consistent presence of key terms such as "waste reduction," "fertilizer," "sustainability," and "health" in both the word cloud visualizations and topic modeling results underscores the community's positive perception of BSF systems. This recognition provides a favorable foundation for broader adoption of BSF technology. Such perspectives are supported by Nguyen et al. (2015), Parra Paz et al. (2021), and van Huis (2020), who discuss BSF's dual environmental and economic value as part of sustainable waste management strategies. Specifically, Topic 1, which achieved the highest coherence score, illustrates that public sentiment is thematically clear when discussing BSF's dual role in reducing organic waste volumes and producing marketable, high-quality organic fertilizers. These attributes align well with global sustainability objectives, including the United Nations Sustainable Development Goals (SDGs), particularly those targeting responsible consumption and production, waste minimization, and sustainable agriculture (FAO, 2013; Parra Paz et al., 2021; van Huis & Oonincx, 2017).

The emphasis on fertilizer production suggests that the community not only values BSF technology's waste diversion potential but also recognizes its contribution to local economic growth through the sale and use of organic fertilizers. This dual-benefit perception is crucial for encouraging adoption at the grassroots level, as communities are more likely to engage in waste management practices that offer tangible economic returns. These findings imply that further scaling of BSF-based systems could contribute significantly to Bandung's waste management infrastructure, reduce landfill dependency, and provide additional income streams for local farmers and waste operators.

4.2. Addressing Community Concerns

Despite the overall positive outlook, the results highlight several significant concerns that must be addressed to ensure the successful implementation of BSF maggot technology. The most prominent of these is odor management, which emerged as a recurring theme in both the word cloud visualizations (Figure 2) and Topic 0 of the LDA model. The respondents expressed apprehension about potential unpleasant odors emitted from BSF processing facilities, which could negatively affect community acceptance. This finding aligns with previous research by Chia et al. (2020) and Gold et al. (2020), who similarly emphasized the role of odor control in increasing public trust and preventing resistance to organic waste processing facilities.

To mitigate these odor-related concerns, practical solutions such as the installation of enclosed processing systems and similar odor mitigation strategies were validated in studies by Banks et al. (2021) and Gold et al. (2020), implementation of biofiltration units, and maintenance of stringent hygiene protocols are recommended. Banks et al. (2021) demonstrated that enclosed systems and biofilters effectively reduce odor emissions, improving environmental quality and community perceptions. Furthermore, the prominence of terms such as "education" and "knowledge" in the word cloud suggests that a lack of awareness and technical understanding may contribute to public skepticism regarding BSF technology. Educational initiatives such as community workshops, informational campaigns, and hands-on demonstrations can bridge these knowledge gaps and build public confidence. Lalander et al. (2019) and Beesigamukama et al. (2020) emphasize the importance of knowledge dissemination efforts in enhancing public trust, particularly when introducing innovative waste management technologies.

Additionally, logistical concerns surrounding the availability of organic waste feedstock and maggot larvae, as highlighted in Topic 2, necessitate the development of reliable supply chain frameworks. Local governments and waste management stakeholders should collaborate to streamline the sourcing and distribution of organic waste, ensuring that BSF systems operate efficiently and without interruption. Addressing these operational challenges will be key to maintaining consistent community support.

4.3. Regulatory Frameworks

The results also underscore the critical need for clear and supportive regulatory frameworks. This mirrors findings by Liu et al. (2021) and Parodi et al. (2022), emphasizing that regulatory support is essential for widespread BSF adoption, which was a recurring theme in Topic 4 and further validated by the low perplexity score observed in the model evaluation. The community's emphasis on terms such as "regulation," "government," "support," and "policy" reflects widespread expectations for formal government involvement and regulatory clarity to facilitate BSF maggot adoption. The respondents articulated a

clear demand for structured guidelines, safety standards, and institutional support mechanisms, which is consistent with the findings of Liu et al. (2021) and Parodi et al. (2022).

To address this, local and national governments should prioritize the formulation of comprehensive standard operating procedures (SOPs) specific to BSF maggot processing, covering aspects such as facility operation, waste input standards, odor management, and product quality certification. Moreover, policy interventions should include financial incentives, tax exemptions, and grants to encourage the participation of SMEs and community-based organizations in BSF operations. Establishing legal recognition and formal market mechanisms for BSF-derived products such as fertilizers and animal feed will further increase economic viability.

In addition, integrating BSF technology within broader municipal waste management plans can facilitate coordinated waste collection and processing efforts. By aligning community expectations with institutional policy development, governments can create an enabling environment that fosters the sustainable growth of BSF systems while addressing the operational, environmental, and socioeconomic concerns identified in this study.

5. Conclusions

This study demonstrated that the utilization of black soldier fly (BSF) maggots offers a viable and sustainable solution for organic waste management in Bandung, West Java, Indonesia. The survey-based analysis revealed strong community recognition of the environmental and economic benefits of BSF maggot systems, particularly in terms of reducing organic waste volumes and producing high-quality organic fertilizers. Additionally, the public acknowledges the contribution of BSF technology to improved public health through enhanced sanitation and pollution mitigation.

However, despite the community's favorable outlook, several challenges require immediate attention to ensure the long-term success and acceptance of BSF maggot systems. Odor management remains a critical concern, with respondents expressing apprehension regarding unpleasant odors emanating from processing facilities. Logistical issues related to the availability of organic waste feedstock and maggot larvae were also identified, posing a risk to the consistent operation of BSF systems. Furthermore, the demand for clear regulatory frameworks, supportive government policies, and educational initiatives was strongly emphasized throughout the responses.

In conclusion, while BSF maggot utilization presents significant potential for addressing waste management challenges and aligns with global sustainability targets, targeted interventions in odor control, supply chain reliability, regulatory clarity, and public education are essential. Addressing these issues holistically will enhance community acceptance, support wider adoption, and contribute to the long-term sustainability of BSF-based waste management strategies.

6. Recommendations

6.1. Community Engagement

On the basis of these findings, increasing public awareness and understanding is crucial to overcoming knowledge gaps and ensuring community support. Local governments, academic institutions, and waste management organizations are recommended to collaborate to initiate educational programs, community workshops, and awareness campaigns. These initiatives should focus on providing comprehensive information regarding the environmental, economic, and public health benefits of BSF maggot technology. Additionally, odor mitigation strategies, safe processing practices, and the value of BSF-derived products such as fertilizers and animal feed should be emphasized. Previous studies by Lalander et al. (2019) and Beesigamukama et al. (2020) highlight that effective knowledge dissemination and public engagement significantly improve the acceptance of innovative waste management systems.

6.2. Research Initiatives

Further empirical research is needed to enhance the efficacy and acceptance of BSF maggot systems. Specifically, future studies should focus on evaluating the long-term effects of BSF fertilizers on soil health, crop yield, and overall agricultural productivity. This research provides scientific validation, thereby addressing the uncertainties identified by community respondents in this study. Moreover, optimizing BSF breeding models, waste collection mechanisms, and feedstock sourcing frameworks is essential to ensure operational efficiency and scalability. Research should also explore best practices for integrating BSF maggot production into existing municipal waste management infrastructures. Prior studies by Sarpong et al. (2023) and van Huis & Oonincx (2017) underscore the importance of continued research to maximize the environmental and economic potential of BSF systems.

6.3. Policy development

Government involvement is paramount in formalizing and supporting the adoption of BSF technology. Policymakers should develop and implement comprehensive policy frameworks that include clear regulatory guidelines, operational standards, and safety protocols specific to BSF maggot processing. Additionally, the introduction of financial incentives, such

as subsidies, tax exemptions, grants, and training programs, will encourage SMEs, cooperatives, and local waste operators to adopt BSF technology. Investment in infrastructure, including waste collection and processing facilities, should also be prioritized. Previous research by Liu et al. (2021) and Parodi et al. (2022) emphasized that a well-structured regulatory environment combined with institutional support is critical to facilitating the large-scale, sustainable deployment of BSF systems.

Ethical Consideration

This research received ethical approval from the Institutional Review Board of Kitakyushu University, Japan. All participants provided informed consent prior to their involvement in the survey. The study maintained the anonymity and confidentiality of all respondents and complied with ethical standards involving human subjects.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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These insights align with findings of Surendra et al. (2016) and Barragán-Fonseca et al. (2017), who emphasized the dual potential of BSF for waste reduction and fertilizer production.

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