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Organic Waste Management with the Pentahelix Model in Bogor City

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Abstract

In Bogor City, the problem of organic waste is worsening, and household food scraps constitute the largest portion. This research investigates the application of Pentahelix model—collaboration between government, private sector, academia, civil society and media—for managing organic waste using Black Soldier Fly (BSF) maggot farming. With a qualitative case study design, the study was conducted from March to May 2025 through interviews and direct observations with Bumi Farm, Siliwangi Waste Bank and Bogor City Environmental Agency. Findings underscore the cooperative contributions of different stakeholders towards valorization of waste into animal feed, organic fertilizer, and antiseptic oils. It was found that collaboration of various stakeholders based on Pentahelix approach does not only enable effective sustainable waste management but also drives innovative circular economy on a shared responsibility basis. The study suggests this approach as a strategic guide for tackling comparable issues in urban settings.

Keywords
Organic Waste, Pentahelix Model, Black Soldier Fly, Circular Economy, Bogor City

1. Introduction
Waste is a major problem (Oliveira et al., 2017). Based on data from the National Waste Management System (SIPSN), waste generation in Bogor City increased from 245,922.33 tons in 2021 to 284,641.60 tons in 2024 (SIPSN, 2024). Can cause environmental pollution (Planche et al., 2025). The composition of waste is dominated by organic waste (Muurmann et al., 2025). Especially food waste 40% with the largest source from household waste 53.79% (SIPSN, 2024). Coordinated waste management between sectors is important and needed (Elza et al., 2023). considering the pile of waste that continues to increase every year (Manan et al., 2024).

Coordinated waste management requires cross-sectoral collaborative efforts.(Rowan, 2025)**.** The Pentahelix model is a strategic approach (Mahendra & Harisoesyanti, 2023)**.** involves five main elements: government, academics, business actors, communities, and media (Planche et al., 2025). This collaboration emphasizes the role of each

stakeholder in creating a sustainable, innovative, and broad-impact organic waste management system. (Alamanda et al., 2020)**.**

The main reason for this study is the gap in research related to the implementation of a collaborative approach. Several previous studies have raised the role of the community through empowerment pemberdayaan Listyandini et al., (2018) and Sukamdani et al., (2022) conducted an evaluation of local governments for their waste management. Zulkifli & Kusnaedi, (2024). even recommend technical solutions such as the circular economy approach at the village level Sapanli et al., (2023). In addition, , Putra (2025) has also strengthened the discourse on environmental management based on collective action. These approaches are still separate and do not reflect the systemic interrelationship between today's Pentahelix elements in the city of Bogor for organic waste management. Meanwhile, Ramdhan & Hermawan, (2022) argue that the dominance of the sectoral paradigm in a region is an obstacle to waste management.

Several studies have shown that there has been no comprehensive application of the Pentahelix model in organic waste management, especially involving five main elements (government, community, academics, business actors, and media) in an integrated manner. This study aims to fill this gap by exploring collaborative strategies based on the Pentahelix model that can create a sustainable, innovative, and participatory organic waste management system in Bogor City.

1.1 Objectives

This study aims to explore and analyze a collaborative approach based on the Pentahelix Model in managing organic waste in Bogor City. The main focus is on the integration of the roles of the five Pentahelix elements consisting of government, academics, business, society, and media. in creating a sustainable, innovative, and participatory management system. It is expected that this study can provide an original model in the form of a collaborative answer to the challenges of fragmentation among stakeholders while increasing multi-sectoral synergy in locally based organic waste management.

2. Literature Review

2.1 Pentahelix Model

The Pentahelix mode (Figure 1) is a cross-sector collaborative approach involving five elements: government, academics, business actors, communities, and media (Kismartini et al., 2023). The government plays a role in regulation and facilities (Vu & Chi, 2024). Academics contribute to research and innovation (Saleh, 2017). Business actors provide technology and investment (Vu & Chi, 2024). Communities become agents of change in the field (Vu & Chi, 2024). Media disseminates information and shapes public opinion (Alamanda et al., 2020). This collaboration produces a system of solutions that are sustainable and responsive to environmental issues (Mahendra & Harisoesyanti, 2023)

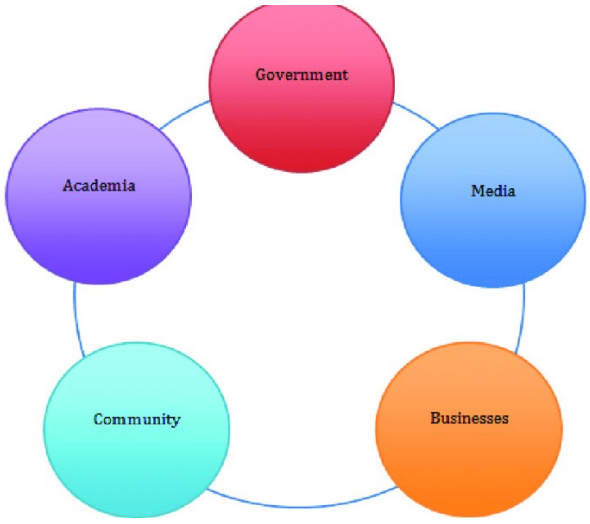
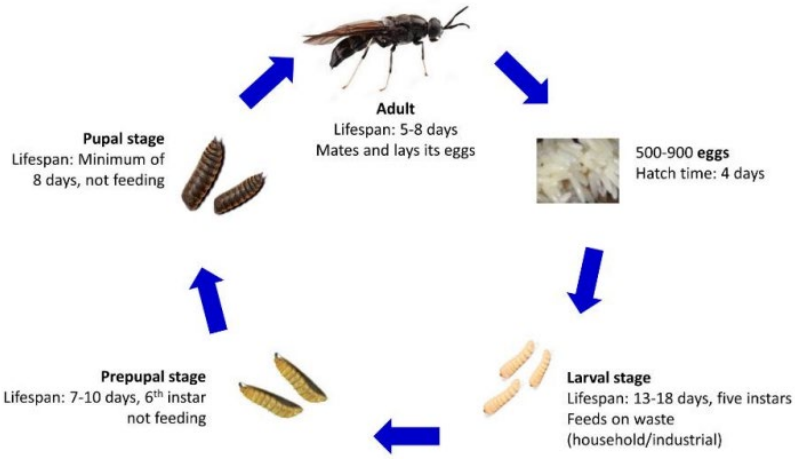


Figure 1. Pentahelix Model

2.2 Maggot Black Soldier Fly (BSF)

Maggots or BSF fly larvae are effective in decomposing organic waste and do not transmit disease (Putri et al., 2023). BSF cultivation can reduce household waste and produce quality animal feed because of its protein (Figure 2), fat, and mineral content (Listyandini et al., 2018). Its life cycle consists of eggs, larvae, pupae, to adults, with the larval phase as the main stage in decomposition for about two weeks (Sheng et al., 2024). BSF flies are a fast, efficient, and environmentally friendly waste treatment solution (Hu et al., 2024).



Feature 2. Life Cycle of BSF Fly

2.3 Bioconversion of Organic Waste through BSF Maggots

Bioconversion is a method of biological waste processing without oxygen, by utilizing organisms such as larvae.*Black Soldier Fly*(BSF) (Surendra et al., 2020). This process is not only effective in reducing waste volume (Siddiqui et al., 2024) but also produces valuable products such as animal feed and organic fertilizer (Gautam et al., 2025).

3. Methods

3.1 Time and Location of Research

This research was conducted in the area of Jl. Gunung Gadung, Legok Muncang Village RT 02 RW 15, Cipaku Village, South Bogor District, Bogor City. The research activities took place during the period March to May 2025.

3.2 Types and Approaches of Research

This study uses a qualitative descriptive method with a case study approach to examine in depth the implementation of the Pentahelix Model collaboration in waste management in Bogor City.

3.3 Data Types

This research relies on two main types of data, namely primary data and secondary data.

a) Data Primer

Data were obtained from the first source (Muurmann et al., 2025).obtained through interviews and direct observation of five stakeholders, namely business actors (Bumi Farm), communities (Siliwangi Waste Bank), local governments, academics, and the media. The aim is to understand the bioconversion process and the implementation of the Pentahelix Model in organic waste management.

b) Data Seconds

Data derived from research results or information that has been previously published by other parties (Gandhy et al., 2024). This research was obtained from scientific journals, government reports, environmental data from the Ministry of Environment and Forestry (including SIPSN), internal documents of Bumi Farm, Siliwangi Waste Bank, Environmental Service as well as media articles and digital publications related to waste management and the role of collaborative actors.

3.4 Data analysis methods

Data analysis was conducted qualitatively with a thematic approach, tracing patterns of meaning from interview results and observations related to the application of the Pentahelix Model in organic waste management. The process includes three stages:

1) Data reduction, namely filtering and classifying relevant information (Sarosa, 2021). According to the role of Pentahelix actors (government, academics, business actors, communities, media) (Flechas, 2023).
2) Data presentation, in the form of narrative descriptions and thematic tables to display collaboration patterns between actors (Saleh, 2017).
3) Drawing conclusions and verification, by formulating findings based on the effectiveness of cooperation, as well as triangulating data from interviews, observations, and documents to ensure validity (Kurniasih et al., 2021).

This approach is used to assess the extent to which Pentahelix synergy forms an inclusive and sustainable organic waste management system in Bogor City.

4. Data Collection

Data collection in this study was carried out using two main methods, namely:

4.1 Interview

A Q&A session was conducted with the resource persons (Landells et al., 2025). The researchers conducted in-depth interviews with various Pentahelix actors, namely: business actors (Bumi Farm), communities (Siliwangi Waste Bank), and government (Bogor City Environmental Service). This interview aims to explore the role of each actor in the Pentahelix Model collaboration and to gain a direct understanding of organic waste management practices through Black Soldier Fly (BSF) maggot cultivation.

4.2 Observation

Field visits were conducted directly to the location (Landells et al., 2025). Namely Bumi Farm, Siliwangi Waste Bank and the Environmental Service to directly observe waste management activities, starting from the collection process, processing, to the final utilization of organic waste.

5. Results and Discussion

This section presents the results of observations on the implementation of the Pentahelix Approach in managing organic waste in Bogor City. The five main elements, including government, academics, business actors, civil society, and the media complement each other in building a sustainable waste management system. This description is arranged according to the contribution of each actor along with the pattern of collaboration between sectors.

5.1 Government

As highlighted by (Kismartini et al., 2023), the Bogor City Environmental Agency (DLH) has been specifically mandated for waste management with the function of formulating and implementing strategies in policies that need to be planned and implemented. In fact, DLH also acts as a policy maker as well as a coordinator, educator, mediator between relevant government agencies, stakeholders including the community, and non-governmental organizations (Elza et al., 2023). DLH developed and implemented Bogor City Regulation Number 6 of 2019 concerning Waste Management with active participation from the community (Lase & Ndraha, 2023). In addition, DLH provides facilities for processing organic waste through the development of environmental organic waste composting which has now advanced to inorganic waste plus organic waste through composting, fermentation, and maggot cultivation for animal feed and fertilizer (Elza et al., 2023). DLH also supports the operation of TPS3R Katulampa which is capable of processing around 1.7 tons per day of organic waste, most of which has been fermented and composted (Elza et al., 2023). DLH has cross-sector partnership initiatives such as the proposed Sedekah Sampah program Sampah (Haryanti et al., 2024). This program involves the community in reducing household waste pollution (Setyoadi, 2018). This program focuses on educating low-level structures on how to separate organic from inorganic waste that is processed in banks to reduce the volume from households.

5.2 Academy

As a higher education institution, Pakuan University plays a strategic role in overcoming organic waste problems through a science and technology approach (Gandhy et al., 2024). The university actively conducts applied research

related to organic waste processing, including the use of Black Soldier Fly (BSF) larvae as a decomposing agent that can be processed into animal feed and organic fertilizer with economic value. In addition, the university has established partnerships with business actors such as Bumi Farm and the Siliwangi Waste Bank community to connect academic theory with field practice. This collaboration also provides opportunities for students to take part in internships, field practices, and applied research that is relevant to community needs. Through this role, Pakuan University ensures that the innovations produced are applicable and can be widely utilized in sustainable organic waste management.

5.3 Business Actors (Bumi Farm)

Bumi Farm is a project-based enterprise located in Bogor that processes organic waste using Black Soldier Fly (BSF) larvae cultivation, implementing a circular economy by converting household and commercial waste into high-value products. Currently, Bumi Farm manages around 600 kg of organic waste daily from two main partner hotels, The 101 Hotel and Bigland Hotel Bogor, as well as from several collaborating Temporary Waste Processing Sites (TPS). The waste collected mainly consists of food scraps that are rich in nutrients and free from harmful chemicals that support optimal growth for larvae. Through a scheduled supply chain system alongside trained personnel, the waste is delivered fresh to ensure efficient fermentation and maggot cultivation.

Bumi Farm utilizes 200 to 300 kg of fresh and active maggots daily, which requires about 50 to 120 grams of maggot eggs depending on the cultivation conditions. Other by-products include dried maggots used for fish and poultry feed, organic fertilizer, and maggot flour and essential oils produced in collaboration with Bank Sampah Siliwangi for natural wound healing. The cultivation process follows a closed system with a cycle of about 15 days. During this period, 10 grams of BSF eggs can process about 100 kg of organic waste per cycle, allowing for rapid and environmentally friendly waste reduction. From Bumi Farm's perspective, it plays a role as a driver in the environmental entrepreneurship business that not only manages waste but creates new opportunities in the agriculture and fisheries sectors.

5.4 Community

Bank Sampah Siliwangi (BSU) utilizes the active involvement of community members as the main source of organic waste by practicing waste sorting at home (Zulkifli & Kusnaedi, 2024). Organic waste collection involves vegetables and fruits that are handed over at designated locations to feed the Black Soldier Fly larvae pest maintenance (Gandhy et al., 2024). The results of the bioconversion have economic value, supporting partners such as Bumi Farm who process these materials. Residents receive incentives in the form of points or goods, creating a local economic cycle while encouraging pro-environmental behavior. BSU acts as an intermediary between residents and processors, providing an example of Pentahelix collaboration with tangible results. The amount of organic waste collected by BSU reaches 50–100 kilograms per day, sufficient for the larval maintenance process with 10–20 grams of BSF eggs producing 25–80 kg of fresh larvae per cycle. Regular education accompanied by environmental leader programs at the neighborhood level raises higher awareness among people, encouraging them to sort waste that reduces waste destined for landfills while building a community-based circular economy system. Maggot farming produces dried maggots, maggot flour, and antiseptic essential oil, which are produced by Bumi Farm and provide a source of income and business opportunities for the community. The profits from waste processing finance social activities and community empowerment. In this case, BSU Siliwangi not only provides environmental cleanliness, but also creates sustainable social innovations that meet local needs. With this collaboration and empowerment approach, BSU has demonstrated the strategic impact of the community for real change with a competitive, inclusive circular economy ecosystem at the local level.

5.5 Media

As a means of mass communication, local media such as Radar Bogor play an important role in raising public awareness regarding organic waste management (Nurendah et al., 2023). The media not only conveys information but also shapes public perception and encourages changes in social behavior (Mahendra & Harisoesyanti, 2023). Radar Bogor actively covers community activities, environmental concerns through the efforts of several entrepreneurs, innovations from academics, and so on (Nurendah et al., 2023). Through collaboration with the Environmental Service and various communities, this media supports campaigns such as Bogor Bebas Sampah, household waste separation movements, and the use of organic fertilizers to increase public participation. In addition, Radar Bogor presents inspiring stories about residents and entrepreneurs who have successfully managed organic waste including maggot

cultivation which has economic value and is beneficial for the environment. With its informative coverage, this media contributes to maintaining collective concern and building an environmentally friendly culture in the community.

The Pentahelix approach to managing organic waste in Bogor City combines the utilitarian roles of government, business, educators, communities, and media, working in harmony. Local governments provide policies and infrastructure for waste management while academics implement innovative technologies based on research. Businesses focus on waste management efforts oriented towards a circular economy. Community leaders encourage local involvement in waste sorting and processing while the media amplifies public awareness campaigns. The Nolongan Intersection has helped create an effective, sustainable system for managing organic waste that reduces waste and empowers the community economy.

6. Conclusion and Sugestion

6.1 Conclusion

The study shows that the implementation of a collaborative approach with the Pentahelix model in managing organic waste in Bogor City has produced significant results. The synergy of the government, academics, business practitioners; society and the media creates a holistic ecosystem in dealing with organic waste problems. Such collaboration not only improves the efficiency of waste management but also creates opportunities for economic innovation through the utilization of BSF larvae and efficient bioconversion systems.

This model shows that environmental management initiatives tend to be more successful when implemented within a multi-stakeholder framework. Its main strength comes from the combination of education and training, regulation, entrepreneurship, citizen participation, and strengthening public information that supports advocacy functions. Therefore, the Pentahelix approach can be recommended as a strategy designed around the organic waste problem in areas facing similar challenges. This not only provides a cleaner and healthier environment but also builds a sustainable and inclusive circular economy approach.

6.2 Sugestion

Several recommendations can be made to improve the application of the Pentahelix model in organic waste management in light of the study's findings and conclusions:

1. Enhancing Coordination Across Sectors
   Even though there has been evidence of stakeholder synergy, the coordination mechanism between the Pentahelix's five components needs to be formalized. Creating a task force or joint coordination forum can improve consistency, cut down on initiatives that overlap, and guarantee that the roles of all actors are properly aligned.

2. Increasing Community Involvement
   Other urban neighborhoods ought to adopt community-based projects similar to the Siliwangi Waste Bank. Expanding training and incentive-based initiatives can promote household involvement in waste collection and sorting, laying the groundwork for a more robust circular economy.
3. Encouragement and Assistance for Policies
   Additional regulatory incentives should be offered by local governments to assist community organizations and entrepreneurs involved in organic waste. These may consist of tax exemptions, streamlined licensing procedures for companies engaged in maggot farming, or financial support for establishments utilizing BSF bioconversion technology.

4. Collaboration between Innovation and Academics
   Enhancing waste processing technologies should remain a top priority for academic institutions and research centers. To create scalable, effective, and affordable solutions, cooperative research projects involving government and business actors are required.

5. Enhanced Media Role in Behavioral Change
   The media needs to expand its function from reporting to implement behavior change communication approaches. The media should develop educational campaigns and digital storytelling approaches together with success story features which will help build environmental responsibility across the population.

6. Replication to Other Cities
   The successful implementation of the Pentahelix model in Bogor demonstrates that local governments throughout the region should implement this collaborative system for their waste management issues. The evaluation processes for pilot initiatives need to be established alongside monitoring systems to guarantee their effectiveness.

The recommendations presented here work to deliver practical steps for government officials together with field experts and academic scholars to maintain the development of the Pentahelix model as an enduring and community-focused system for organic waste management.

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Biographies

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Abel Gandhy is lecturer in Management Study Program at Pakuan University where he heads the Quality Assurance Unit. Dr. Abel teaches course on Marketing Management, Entrepreneurship, Introduction to Business and Management, Macroeconomics and Microeconomics. He received Ph.D. in Agricultural Economics from Bogor Agricultural University. He also received Magister Management from Business School of Bogor Agricultural University. His key research area is Marketing Research and International Trade.