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Integrated Zero-Waste System Utilizing Food Waste-Derived Maggot and Wastewater-Cultivated Azolla as Alternative Feed for Fish Farming in Joho Village, Banjarnegara Regency

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Abstract
The aquaculture sector faces a major challenge from feed costs, which can reach 60–70% of total operational expenses, while Joho Village, Bawang Subdistrict, Banjarnegara Regency, has been designated as a strategic area for fisheries and agricultural development. This study aimed to develop an integrated zero-waste system utilizing food waste-derived maggot (Black Soldier Fly larvae) and wastewater-cultivated Azolla microphylla as an alternative feed for fish farming. The research was conducted from June to August 2026 through several stages: material preparation, waste management using maggot, utilization of fish pond wastewater for Azolla cultivation, alternative feed formulation, and community outreach. A total of 250 grams of BSF larvae were fed 500 grams of leftover rice daily for seven consecutive days to assess waste consumption rate, while 100 grams of Azolla seedlings were cultivated in tilapia pond wastewater for five days. Results showed an average waste consumption rate of 88.97%, with the highest rate of 90.60% recorded on day three, confirming the high efficiency of maggot as an organic waste decomposer. Azolla successfully functioned as a phytoremediation agent, neutralizing pond water odor while achieving optimal biomass growth without special treatment. The maggot and Azolla mixture at a 1:1 ratio produced a nutrient-balanced alternative feed rich in both animal and plant protein. Community outreach demonstrated high enthusiasm among local farmers and increased awareness of waste-based feed alternatives. These findings recommend the adoption of this integrated system as a model for independent, environmentally friendly feed production at the village level.

Keywords: *azolla microphylla; alternative fish feed; black soldier fly; zero-waste system*

INTRODUCTION

Joho Village, located in Bawang Subdistrict, Banjarnegara Regency, has been officially designated as a strategic service center for agricultural and fisheries development under Regional Regulation of Banjarnegara Regency No. 25 (2002). This designation reflects the local government's recognition of the village's potential in supporting regional food security through both crop cultivation and freshwater fish farming. Encouraged by this status, a considerable number of residents in Joho Village have engaged in tilapia (Oreochromis niloticus) cultivation as a supplementary or, in some cases, primary source of household income. Fish farming in this village is generally conducted on a small scale, managed independently by individual households or small farmer groups, using simple earthen or concrete ponds located adjacent to residential areas. This close proximity between ponds and homes reflects the informal, subsistence-oriented nature of aquaculture practiced in the village, where farming decisions are often made based on available resources and traditional knowledge rather

than formal technical training.

Despite this developmental potential, fish farmers in Joho Village continue to face persistent structural challenges that limit the long-term sustainability and profitability of their aquaculture activities. The most significant of these is the high cost of commercial fish feed, which can account for 60% to 70% of total operational expenses (Zega et al., 2025). Most farmers in the village rely entirely on factory-produced pellet feed, the price of which is subject to fluctuations in raw material costs such as fishmeal and soybean meal, both largely imported commodities whose prices are influenced by global market conditions beyond the farmers' control. This dependency places small-scale farmers in a financially vulnerable position, as rising feed prices are rarely accompanied by a proportional increase in the selling price of harvested fish at the local market, gradually eroding farmers' profit margins. In several cases, this economic pressure has discouraged continued participation in aquaculture altogether, prompting some residents to abandon their ponds or reduce stocking density, which in turn limits the growth of the fisheries sector that the village has been designated to develop.

Alongside the feed cost problem, Joho Village also faces an unresolved issue of organic waste accumulation, both from households and from fish farming activities themselves. Domestic waste, particularly leftover rice and kitchen scraps, is commonly discarded without any further processing, despite representing a substantial and renewable source of organic material that could otherwise be converted into economically valuable products. In many households, this waste is simply thrown away or left to decompose in open spaces, contributing to unpleasant odor and the potential breeding of disease vectors such as flies. At the same time, wastewater generated from tilapia ponds, containing residual uneaten feed, fish feces, and decomposing organic matter, is typically discharged directly into surrounding drainage channels or left stagnant within the ponds themselves. Over time, this practice leads to a buildup of nitrogenous compounds and phosphorus in the water, resulting in unpleasant odor, deteriorating water quality, and potential harm to both the aquatic ecosystem and the health of the cultured fish. These two forms of waste, domestic and aquacultural, are seldom managed through a coordinated system in Joho Village, and are instead treated as separate, unavoidable byproducts of daily life rather than as potential resources that could be redirected back into the local economy.

This situation in Joho Village mirrors a broader pattern observed in many rural fishery communities across Indonesia, where limited access to affordable feed alternatives and the absence of adequate waste management infrastructure tend to occur simultaneously, yet are rarely addressed through an integrated approach. Existing interventions in similar rural contexts often focus narrowly on either feed substitution or waste treatment in isolation, without recognizing that the two problems can, in fact, be resolved through a single interconnected system, particularly at the scale of a single village where resources, land, and community cooperation are more readily coordinated than at larger institutional or industrial scales. This gap highlights the need for locally grounded solutions that do not merely transfer technology developed elsewhere, but are adapted to the specific material conditions, available infrastructure, and social dynamics of villages such as Joho.

In response to this locally specific condition, an integrated waste-based feed approach was developed for Joho Village, drawing on two biological agents that are both low-cost and technically accessible to rural households: Black Soldier Fly (BSF) maggot and Azolla microphylla. Maggot cultivation was selected primarily because it requires minimal infrastructure, using simple, repurposed containers such as used mineral water bottles or gallons, materials that are readily available and familiar to residents of Joho Village, thereby lowering the barrier to entry for farmers with limited capital. Maggot are also known for their rapid bioconversion capacity, capable of reducing organic waste mass by up to 85% within a relatively short cultivation period (Asrowi & Farida, 2024), making them well suited to the volume and type of domestic waste typically generated by village households. Beyond its function as a waste decomposer, maggot biomass itself possesses high crude protein content, ranging from 45% to 60% in dried form, and natural antimicrobial compounds that have been reported to enhance disease resistance in cultured fish (Alazhar et al., 2026), offering an added nutritional and health benefit beyond simple waste reduction.

To address the wastewater component of the problem, Azolla microphylla was introduced as a complementary agent specifically suited to the condition of tilapia ponds in Joho Village. Owing to its symbiotic association with the nitrogen-fixing cyanobacterium Anabaena azollae, Azolla is able to grow rapidly while simultaneously absorbing excess nitrogen and phosphorus from pond wastewater, functioning as a natural, low-maintenance phytoremediation agent (Diniariwisan et al., 2022). In addition to improving water quality, Azolla also produces plant-based biomass with a relatively high protein content, ranging from 23% to 35% (Fakhri et al., 2025; Handajani, 2012), positioning it not

only as a bioremediation tool but also as a nutritionally valuable feed input. This dual function is particularly advantageous for a village setting such as Joho, where farmers generally lack access to mechanical or chemical water treatment technologies and instead require a solution that can operate passively, using materials and space already available within the household environment, without demanding continuous monitoring or specialized skills.

By integrating these two locally adaptable agents, food waste-derived maggot and wastewater-cultivated Azolla, this study seeks to design a zero-waste system tailored specifically to the socio-environmental conditions of Joho Village, in which feed cost reduction and waste management are treated not as separate problems but as two complementary components of a single circular economy model implemented at the household and village level. This study further aims to evaluate the technical performance of this system, particularly the waste consumption rate achieved by maggot and the growth effectiveness of Azolla under local pond wastewater conditions, as well as to formulate a balanced alternative feed from the combination of both materials. Finally, this study assesses the extent to which community outreach conducted in Joho Village can increase farmers' awareness and encourage the adoption of this waste-based alternative feed as part of a self-sufficient, environmentally sustainable village development model.

METHOD

This study utilized Black Soldier Fly (BSF) maggot and Azolla microphylla for waste-based alternative fish feed production. The activity was conducted from June to August 2026 in Joho Village, Bawang Subdistrict, Banjarnegara Regency, an area designated for fisheries sector development in accordance with the regional spatial planning regulation (Regional Regulation of Banjarnegara Regency No. 25, 2002). The research stages consisted of material preparation, waste management using maggot, utilization of fish pond wastewater for Azolla cultivation, alternative feed formulation, and community outreach for the residents of Joho Village.

Material Preparation

The BSF maggot and *Azolla microphylla* used in this study were sourced from cultivation farms in Cilacap City, Central Java, and purchased through an online shop, as no BSF maggot breeders or Azolla microphylla seedlings were yet available in Joho Village. The waste used as maggot feed consisted of domestic waste in the form of collected leftover rice, while tilapia pond wastewater was used as the growth medium for Azolla.

Waste Management Using Maggot

Food waste was collected from domestic waste in the form of leftover rice to serve as a bioconversion substrate (Asrowi & Farida, 2024). The maggot used consisted of 250 grams of BSF larvae, which were fed leftover rice at a rate of twice their body weight (Sartika et al., 2024). A total of 500 grams of collected leftover rice was provided to the maggot to determine their waste consumption rate. Used Le Mineral bottles were employed as the growth medium for the maggot.

Utilization of Fish Pond Wastewater for Azolla Cultivation

Azolla was cultivated in a dedicated pond utilizing wastewater from tilapia farming as a source of nitrogen and phosphorus nutrients (Diniariwisan et al., 2022). Azolla seedlings were sown at a quantity of 100 grams with a water depth of 12 cm into used Le Mineral bottles containing tilapia farming wastewater. The Azolla was kept in a shaded location, protected from direct sunlight. Feed production began with mixing maggot and Azolla at a ratio of 1:1. Both ingredients were ground using a mortar and pestle to ensure even distribution of nutrient content and to facilitate easier digestion by the livestock. The ground feed also made feeding more convenient for farmers.

Community Outreach for Joho Village Residents

The outreach activity was conducted at the Joho Village Hall, Bawang Subdistrict, Banjarnegara Regency. The target group of the program comprised community members working as livestock farmers who demonstrated strong willingness to utilize maggot and Azolla as an alternative, highly nutritious, and environmentally friendly livestock feed. This outreach on waste processing using maggot and Azolla as livestock feed is expected to enable independent waste utilization among the residents of Joho Village. The indicators of this outreach activity are presented in Table 1.

Table 1. Indicators of Outreach Activity

Partner Condition	Before	After
Knowledge of the utilization of waste by maggot and Azolla for alternative livestock feed	Not yet understood	Awareness of the importance of production regarding the utilization of waste by maggot and Azolla for alternative livestock feed
Knowledge of the nutrient content of maggot and Azolla as alternative feed	Not yet understood the nutrient content contained in maggot and Azolla	Knowledge of the nutrient content in maggot and Azolla
Knowledge of the availability of alternative feed from maggot and Azolla	No one had yet combined maggot and Azolla for alternative livestock feed	Possess knowledge that maggot and Azolla can be combined for alternative livestock feed

The integration of food waste bioconversion through maggot and phytoremediation of fish pond wastewater using Azolla in Joho Village is expected to create an independent and environmentally friendly aquaculture ecosystem. Through this research procedure, the effectiveness of the zero-waste system can reduce domestic waste and wastewater generated from fish farming.

RESULTS AND DISCUSSION

Waste Consumption Rate by Maggot

The waste consumption rate by maggot was tested over seven consecutive days. A total of 250 grams of maggot were fed rice at twice their body weight, namely 500 grams per day (Sartika et al., 2024), showing varying yet consistently high results in the waste consumption rate presented in Table 2. The results over the seven consecutive days showed variation in the consumption rate. The waste consumption rate by maggot was calculated using the following formula (Purnama et al., 2025):

$$\%\ \text{Waste Consumption Rate} = \frac{(\text{Initial feed weight} - \text{Final feed weight})}{(\text{Initial feed weight})} \times 100\%$$

Figure 1. The highest consumption rate occurred on the third day at 90.60%.

Based on the results obtained, the highest consumption rate occurred on the third day at 90.60%, as documented in the Figure 1. indicating the most optimal outcome for the consumption rate. It can be concluded that the bioconversion of 500 grams of leftover rice by 250 grams of maggot demonstrates that BSF larvae are highly efficient decomposers. Maggot exhibit high amylase, lipase, and protease enzyme activity, enabling them to break down carbohydrates and proteins in food waste (Asrowi & Farida, 2024). The use of leftover rice substrate in Joho Village has proven capable of significantly reducing waste mass.

Table 2. Waste Consumption Rate by Maggot over 7 Days

Day	Initial feed weight (gram)	Final feed weight (gram)	Waste consumption rate (%)
1	500	52	89,60
2	500	60	88,00
3	500	47	90,60
4	500	59	88,20
5	500	51	89,80
6	500	59	88,20
7	500	58	88,40
Average waste consumption rate			**88,97%**

Growth of *Azolla microphylla* in Fish Pond Wastewater

The growth of *Azolla microphylla* in wastewater from Azolla cultivation in Joho Village utilized tilapia pond wastewater as the primary nutrient source. Azolla functions as a phytoremediation agent that absorbs nitrogen and phosphorus from fish feces, thereby improving water quality. This plant is able to proliferate rapidly due to its symbiosis with *Anabaena azollae*, which fixes nitrogen from the air (Diniariwisan et al., 2022). *Azolla microphylla* seedlings sown in used Le Mineral gallon containers, at a weight of 100 grams and a water depth of 12 cm using pond wastewater, proved effective in increasing Azolla population. The Azolla population increased from the initial seeding stage, with the water surface in the gallon initially exposed before gradually becoming fully covered by Azolla growth until reaching a saturation point. At the saturation point, the increase in Azolla population ceased, and additional gallon containers filled with pond wastewater were introduced as further propagation media. The increase in Azolla population can be seen in the Fig. 2.

Figure 2. Increase in *Azolla microphylla* population within a period of 5 days.

Within a period of 5 days, the growth of Azolla in fish pond wastewater proved effective, as shown in Fig. 1. Azolla placed in a shaded location, protected from direct sunlight, was able to grow optimally without any special treatment, accompanied by dense and elongated root development. The Azolla that grew exhibited a bright green color, with some specimens turning brown once the propagation gallon reached saturation. The growth of Azolla can be seen in the Figure 3.

Figure 3. The shape of the leaves and roots of the *Azolla microphylla* seedlings

In water where Azolla had grown, the fishy odor generated from tilapia pond wastewater disappeared and was proven to be neutralized. The assessment was conducted qualitatively by comparing the odor of pond water before and after Azolla growth. Phytoremediation, as documented in the literature, is proven effective in decomposing waste generated by Nile tilapia pond farming.

Livestock Feed Production from Maggot and *Azolla microphylla*

The mixing of maggot and Azolla at a 1:1 ratio, as documented in the Fig. 4., in Joho Village created a balanced feed formula. Maggot contributed animal protein and essential amino acids, while Azolla provided plant protein, vitamins, and minerals. This system supports a circular economy, in which household organic waste is converted into feed, and pond wastewater is processed into plant biomass that can be re-harvested (Asrowi & Farida, 2024).

Figure 4. The shape of the Livestock Feed Production from Maggot and *Azolla microphylla*

Outreach on the Utilization of Domestic Household Waste and Fish Pond Wastewater

The outreach conducted in Joho Village demonstrated high enthusiasm among the farmers. The community began to realize that kitchen waste, previously discarded, could be utilized as livestock feed through maggot and Azolla. With appropriate policy support, Joho Village has the potential to become a model of a self-sufficient feed-producing village based on environmental sustainability and local biotechnological innovation.

Figure 5. The outreach conducted in Joho Village demonstrated high enthusiasm among the farmers

CONCLUSION

This study demonstrates that the integration of Black Soldier Fly (BSF) maggot and *Azolla microphylla* can create an effective zero-waste system to address domestic waste and fish pond wastewater problems in Joho Village, Bawang Subdistrict, Banjarnegara Regency. Testing results over 7 days showed that 250 grams of BSF maggot were able to consume leftover rice with an average waste consumption rate of 88.97%, with the highest rate achieved on the third day at 90.60%, confirming the efficiency of maggot as an organic waste decomposer owing to their high amylase, lipase, and protease enzyme activity. On the other hand, *Azolla microphylla* cultivated using Nile tilapia pond wastewater proved to have a dual role: as a phytoremediation agent that absorbs nitrogen and phosphorus, thereby neutralizing the fishy odor of pond water, and as biomass that grew optimally within 5 days without special treatment due to its symbiosis with Anabaena azollae. The mixing of maggot and Azolla at a 1:1 ratio produced an alternative feed formula rich in both animal and plant protein, making it a viable, more economical, and environmentally friendly substitute for conventional livestock feed. Overall, this system successfully supports a circular economy model at the village level, in which household waste and fish farming wastewater are converted into value-added resources. The outreach activities conducted for Joho Village farmers also demonstrated enthusiasm and increased community knowledge regarding the utilization of maggot and Azolla as alternative feed. Thus, this integrative approach has the potential to be further developed as a sustainable, self-sufficient feed-producing village model, while also serving as a tangible solution to the high feed costs that have long burdened the aquaculture sector.

DECLARATION OF GENERATIVE AI

The authors declare that no generative AI or AI-assisted technologies were used in the writing process of this manuscript.

CONFLICTING INTEREST STATEMENT

The authors states that there is no conflict of interest in the publication of this article.

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REFERENCES

Alazhar, E., Ramdhani, P., & Tampubolon, M. R. (2026). Kandungan Nutrisi Maggot yang Diaplikasikan pada Budidaya Ikan Lele (*Clarias sp*). *Jurnal Penelitian dan Pengkajian Ilmiah*, *3*(4), 608–613.

Asrowi, B. S., & Farida, I. (2024). Peran Magot sebagai Pengurai Sampah Organik dan Dijadikan Pakan Alternatif Peternakan dan Perikanan. *Prosiding Seminar Nasional Sains dan Teknologi Seri 02*, *1*(2), 724–733.

Dewi, R., & Sylvia, N. (2022). Pengelolaan Sampah Organik untuk Produksi Maggot sebagai Upaya Menekan Biaya Pakan pada Petani Budidaya Ikan Air Tawar. *Jurnal Malikussaleh Mengabdi*, *5*(1), 1–10.

Diniariwisan, D., Batun Citra Rahmadani, T., Sumsanto, M., Ayu Diamahesa, W., Asri, Y., Idris Affandi, R., & Abidin, Z. (2022). Pemanfaatan Tanaman *Azolla pinnata* untuk Menjaga Kualitas Air pada Kolam Pemeliharaan Ikan Platy Pedang (*Xiphophorus helleri*) di Desa Karang Bongkot, Kecamatan Labuapi, Kabupaten Lombok Barat. *Indonesian Journal of Fisheries Community Empowerment*, *2*(3), 158–164.

Fakhri, R. H., Vibowo, H., & Maemunah, S. (2025). Evaluasi Pemberian Pakan Kombinasi Azolla, Magot, dan Pakan Komersial pada Ayam Sentul di Dinas Ketahanan Pangan Pertanian dan Perikanan Kota Tasikmalaya. *Jurnal Sains Terapan: Wahana Informasi dan Alih Teknologi Pertanian*, *15*(2), 8–22.

Febrian, A. M., Syahputra, R., & Hasanah, L. (2024). Optimalisasi Penggunaan Maggot BSF dalam Formulasi Pakan Ikan: Tinjauan Sistematis Literatur. *Jurnal Akuakultur Tropis*, *9*(1), 33–44.

Handajani, H. (2012). Optimalisasi Substitusi Tepung Azolla Terfermentasi pada Pakan Ikan untuk Meningkatkan Produktivitas Ikan Nila Gift. *Jurnal Teknik Industri*, *12*(2), 177–181.

Kementerian Pertanian Republik Indonesia. (2019). *Keputusan Menteri Pertanian Republik Indonesia Nomor 261/KPTS/SR.310/M/4/2019 tentang Persyaratan Teknis Minimal Pupuk Organik, Pupuk Hayati, dan Pembenah Tanah*.

Kusumawati, P. E., Dewi, Y. S., & Sunaryanto, R. (2022). Pemanfaatan Larva Lalat Black Soldier Fly (*Hermetia illucens*) untuk Pembuatan Pupuk Kompos Padat dan Pupuk Kompos Cair. *Jurnal TechLINK*, *4*(1), 1–12.

Mushocheh, A., Febriyanti, T. L., & Qulubi, M. H. (2023). Pemanfaatan Tepung Azolla pada Pakan untuk Meningkatkan Pertumbuhan Benih Nila GIFT (*Oreochromis sp.*). *Jurnal Lemuru*, *5*(2), 213–222.

Pemerintah Republik Indonesia. (2008). *Undang-Undang Republik Indonesia Nomor 18 Tahun 2008 tentang Pengelolaan Sampah*.

Purnama, I., Ruyani, A., Yani, A. P., Johan, H., Parlindungan, D., & Nursa'adah, E. (2025). Giving a Combination of Snails (*Achatina fulica*) and Coconut Dregs on the Growth and Protein Content of Maggots (*Hermetia illucens*). *Acta Aquatica: Aquatic Sciences Journal*, *12*(2), 222–232.

Razid, R., Zulkarnain, D., & Badarudin, R. (2022). Pemanfaatan Limbah Organik Berbeda sebagai Media Budidaya Maggot Black Soldier Fly (*Hermetia illucens*). *Jurnal Ilmiah Peternakan Halu Oleo*, *6*(4), 161–168.

Salman, M., Halawa, Y., & Zega, A. (2023). Implementasi Budidaya Maggot dalam Pengolahan Limbah Pasar dan sebagai Pakan Ikan Ramah Lingkungan di Gunungsitoli. *Jurnal Pengabdian Kepada Masyarakat Maritim*, *4*(2), 77–84.

Santi, S., Mahmud, A. T. B. A., Fausiah, A., & Nursani, N. (2021). Peningkatan Produktivitas Azolla sebagai Pakan Ternak Unggas dengan Penggunaan Pupuk Kandang. *Agrovital: Jurnal Ilmu Pertanian*, *6*(2), 87–95.

Sartika, E., Yuliah, S., Hadiani, F., Binarto, A., & Lusiani, A. (2024). Peluang Ekonomi Budi Daya Maggot melalui Pemanfaatan Sampah Organik di RW 12 Desa Ciwaruga. *Jurnal ABDINUS: Jurnal Pengabdian Nusantara*, *8*(2), 451–461.

Silalahi, W. R. (2025). Ulat Maggot (*Hermetia illucens L*) sebagai Solusi Pengolahan Sampah Organik Rumah Tangga yang Ramah Lingkungan dan Menguntungkan. *Seminar Nasional Pengabdian kepada Masyarakat Universitas Terbuka*.

Wende, J. (2026). Penggunaan Rumput Azolla sebagai Bahan Alternatif dalam Konteks Pertanian Terpadu secara Berkelanjutan: Literature Review. *Inspirasi*, *6*(2), 60–70.

Yusri, A. Y., Nurhidayatullah, N., Jamaluddin, R., & Alimuddin, H. (2022). Pelatihan Pembuatan Pakan Ekonomis Bernutrisi Tinggi Berbahan Dasar Maggot BSF. *Jurnal Pengabdian UNDIKMA*, *6*(1), 1–10.

Zega, A., Gulo, B., Zebua, A. K., & Dawolo, J. (2025). Optimalisasi Kultur Maggot (Black Soldier Fly) sebagai Pakan Alternatif dalam Meningkatkan Pertumbuhan Ikan Budidaya Ramah Lingkungan. *PERAUT: Jurnal Perikanan dan Kelautan*, *2*(1), 81–87.