

Business Innovation in Sustainable Feed: Economic Potential of Converting BSF Maggots into Nutritious Pellets at An-Nur Islamic Boarding School

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Abstract

This community service program sought to help solve the economic problems the An-Nur Ngrukem Islamic Boarding School was facing due to the increasing production of Black Soldier Fly (BSF) maggots. With 50 kg produced daily, the oversupply of maggots became an economic problem, especially because a significant portion could not be sold quickly they were only sold in small quantities for external use and most were internally used as feed. The economic loss posed by unsold maggots and the lost business opportunities as the maggots aged could be addressed through actions taken during this program. Using a Participatory Action Research (PAR) approach, partners were active participants during program preparation, training, technology adoption, and mentoring. Building entrepreneurship, production management, and product innovation were the goals of the program. Students and managers acquired production, management, and technical skills such as rudimentary financial record-keeping, feed formulation, and pellet production. The pellets manufactured commanded a higher market price, raising the selling price from Rp 5,000/kg to Rp 12,000/kg, enabling access to larger markets and providing the pesantren with a reliable income stream. Overall, the program strengthened business innovation and entrepreneurship while broadening the scope of economically focused education. The community-based program integrates entrepreneurship teaching with eco-friendly practices, offering a model that is simple to replicate. In addition, several outcomes directly support Sustainable Development Goals (SDGs): SDG 2 (Zero Hunger) through enhanced feed availability; SDG 8 (Decent Work and Economic Growth) through entrepreneurship development, income generation, and financial literacy; and SDG 12 (Responsible Consumption and Production) through waste reduction and circular-economy-based pellet production. The integration of business management, production processes, and ecological practices demonstrates how BSF-based microenterprises can contribute not only to economic improvement but also to broader sustainable development efforts.

INTRODUCTION

The use of Black Soldier Fly (BSF) larvae in waste management is about minimizing waste while exploring innovative possibilities in this sector. BSF larvae convert most of the organic waste stream into protein biomass that can be used as animal (Wulandari et al., 2022; Yusri et al., 2024)). This is beneficial for International Islamic Schools. They have the potential to be environmentally unsustainable because they produce a significant amount of waste from their cafeteria and kitchen operations. In addition, converting waste into animal feed will increase the profitability of the institution as it can help maintain the economic sustainability of their service provision (Pakpahan et al., 2025).

In previous community service activities, BSF cultivation in community service projects focused on the bottom trap method to help promote awareness and demonstrate the environmentally friendly benefits of breeding trained maggot incubators (Hilmiawan et al., 2024; Simanjuntak et al., 2022; Wardhana et al., 2024). The main drawback in these projects is that almost all activities centered on maggot production. This is problematic mainly because it involves perishable goods and low demand. Related economic challenges include unsold maggot production, lost income potential, and the lack of maggot processing technology to increase overall economic value (Pratiwi et al., 2025; Ramdhani et al., 2024; Sarastuti et al., 2023). The maggot cultivation activity at the An-Nur Ngrukem Islamic Boarding School is capable of producing around 50 kilograms of maggots every day. However, currently, the institution has been distributing fresh maggots mainly in the local area, which has resulted in a significant production surplus and waste. Insufficient production facilities, inadequate knowledge around feed formulation, and the absence of organizational management processes constrains the growth of this potential profit center. Previous programs on this site did not incorporate business and economic conceptual focus. To date, the majority of site projects emphasize technical training and environmental stewardship while neglecting to enhance other critical management functions around business creation, control, and product-market innovation.

There have been several attempts at product diversification, such as maggot flour and fish feed pellets (Bibin et al., 2024; Shofa Robbani et al., 2022), which ignore cost efficiency, market access, product quality, and financial feasibility as crucial business elements. This program's innovation consists of blending business and environmental management. It equips students and managers with the competencies to design novel maggot pellets with enhanced durability and marketability. Publications tend to focus on the immediate applications of training, particularly the adoption of technology and the subsequent economic effects (or lack thereof). It is critical to develop programs that combine technical training with elements of entrepreneurship, management, and market-driven product innovation (Prastiwi et al., 2024). This helps to explain the existing gap.

Therefore, this community service program was designed to combine environmental benefits with business innovation. Its main objective is to build the capacity of students and managers in producing maggot-based pellets with higher market value, while also introducing simple financial management and business practices. This program is aimed at solving waste problems while considering new economic opportunities and encouraging sustainable entrepreneurship development in Islamic boarding schools. All economic benefits obtained by participants in this program, for example, participants earn economic value by converting the maggot blocks they map into products in a shorter cycle, are obtained in terms of value, shelf life, and market reach of the transformed products. The financial and production management systems and product units managed by these students provide institutions with better results and applications in this field. This set of indices, in the context of Islamic boarding schools, is not an indicator in itself, but rather a basis for assessing the program's achievements in terms of economic and institutional resilience in the context of Islamic boarding schools.

IMPLEMENTATION METHOD

The framework for community service activities was developed using the PAR Method, which ensures that community partners are involved in all stages of the process. In this case, community members, available resources, and sustainable community capacity building all assist the community in these efforts. The project location is at the An-Nur Ngrukem Islamic Boarding School, Bantul, Yogyakarta, which is the location of the boarding school's kitchen and daily canteen waste. The main direct partners are the boarding school management unit (UPT) and a team of 15 students selected to form the core team for maggot cultivation and feed processing activities.

This process consisted of four series consisting of socialization, training, technology application, and mentoring-evaluation. Specifically, in the preparation and socialization phase, the service team visited the site, then conducted interviews and focus group discussions with the pesantren leaders, UPT managers, and student representatives. This was to examine the economic and managerial problems concerning the utilization of maggots that they needed to be

solved. For the training stage, we centered our focus on two components: training on the maggot pellet processing, feed formulation, drying and pelletizing techniques and managerial training concerning production planning, basic financial recording, and marketing. During the technology application stage, we set up, and demonstrated the drying and pellet machines, and then engaged in practice sessions to master the technology. For the mentoring and evaluation stage, we conducted prolonged monthly monitoring, which consisted of the service team and partners working on the production flow, scanning the market for feedback, and identifying the gaps together.

The flowchart in Figure 1 illustrates the sequence of activities within the framework. After the problem identification phase, the next steps involve strengthening partner capacity, implementing solutions, and evaluating solutions in terms of sustainability. The proposed solution is to integrate solutions to technical problems with economic opportunities that are accessible to Islamic boarding schools. Therefore, this process addresses economic opportunities simultaneously with problems to avoid exclusive interventions that focus on problem solving.

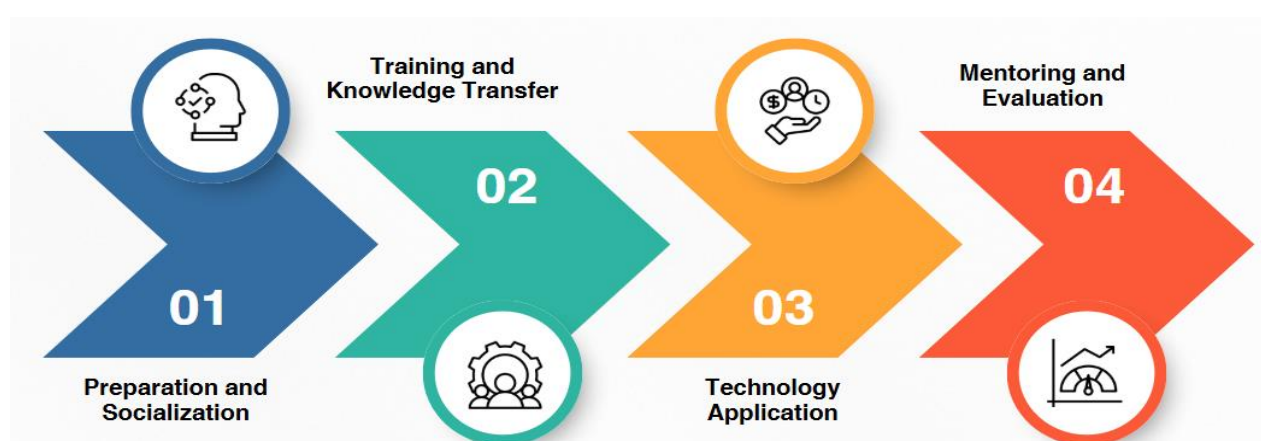


Figure 1. Stages of the Community Service Activities

RESULTS

The community service program at An-Nur Ngrukem Islamic Boarding School involves 15 members consisting of community personnel, staff, and several students who oversee waste management and maggot cultivation activities. Participants consist of 80% men aged between 17 and 40 years. 80% of participants are male and aged between 17 and 40 years. 20% of women are assigned administrative, financial management, and maggot cultivation tasks. The boarding school administrators are students, while the teaching staff consists of individuals with various educational backgrounds.

Table 1. Characteristics of Program Participants

Category	Number	Percentage
<i>Age 17 – 20</i>	10	67
<i>Age 21 – 30</i>	3	20
<i>Age 31 – 40</i>	2	13
<i>Gender (Male)</i>	12	80
<i>Gender (Female)</i>	3	20
<i>Education: High school</i>	10	67
<i>Education: Diploma/Undergrade</i>	5	33

During the socialization session, participants expressed economic risks associated with oversupply of fresh larvae. Upon reflection, participants showed a change in their disposition regarding the appreciation of the importance of innovation during downstream activities in the supply chain, along with the need for better production management.

Table 2. Competency Improvement of Participants (Pre–Post Evaluation)

Competency Area	Pre-Test Score (Avg %)	Post-Test Score (Avg %)	Improvement
BSF processing knowledge	45%	87%	+42%
Feed formulation skills	40%	82%	+42%
Machine operation skills	38%	80%	+42%
Financial recording skills	42%	85%	+43%

The next stage of the training focused on key skill areas in feed formulation and machine operation, where pre- and post-training assessments showed an average improvement from 42% to 85%. Regarding the Practical Competency in Management session that we also discussed, this included basic training on financial record management, stock control, which we also discussed, and inventory management components that we reviewed. See Table 2.

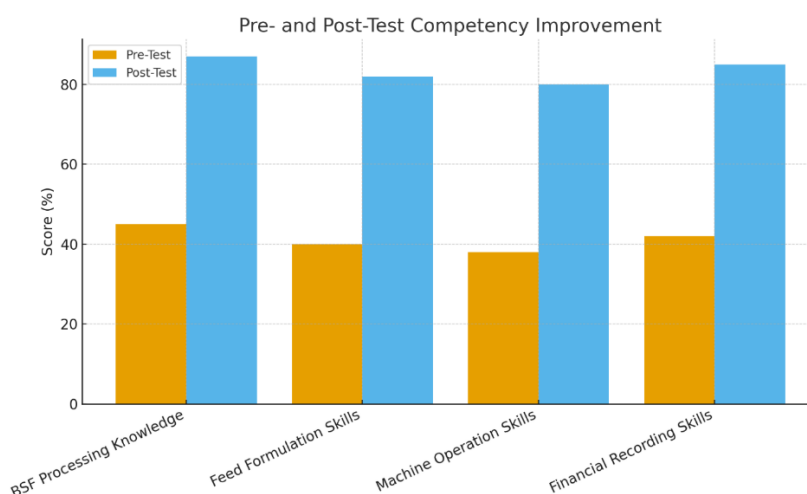


Figure 2. Competency Improvement of Participants (Pre–Post Evaluation)

The implementation of BSF maggot-based pellet production has resulted in a substantial improvement in shelf life, which has increased from 2-3 days with fresh maggots to 2-3 months with pellets. Additional production records show greater economic value: fresh maggots, which were previously sold for IDR 5000/kg, increased to IDR 12000/kg for pelletized maggots, which is an increase of more than 100% to IDR 12000/kg for pelletized maggots.

Table 2. Comparison of Product Value Before and After Program

Product Form	Shelf Life	Selling Price/kg	Market Reach
Fresh maggots	2–3 days	Rp5,000	Local community only
Maggot pellets	2–3 months	Rp12,000	Wider market potential

DISCUSSION

During the assistance and evaluation phase of our community service program at the An-Nur Ngrukem Islamic Boarding School, we observed the social, managerial, and economic transformations brought about by the participants during the program. The most significant of these was the production unit managed by the students, which was also integrated into the organizational structure of the boarding school. This unit is responsible for the operation of the BSF pellet production machine and has taken over the management of pellet production and sales. More importantly, this unit works with students and managers to maintain financial records, cost accounting systems, inventory control, and all key aspects of business sustainability. Participants taught students and business managers about the principles of business sustainability through record keeping, cost accounting systems, and inventory control.

Participants are able to calculate input costs, assess profit margins, create production schedules, and make appropriate pricing decisions, all of which are excellent performance indicators that demonstrate the real value of production to students. Day by day, participants and supervisors are able to refine the business system and discipline to an impressive level. Participants demonstrate entrepreneurial initiative, while supervisors develop control discipline over the daily operations of the business system.

Each day, the maggot farm produces 50 kilograms of maggots, but until now, these maggots have only been used for internal feed and very limited fresh sales. Without financial management, there would be no profit. This results in oversupply, waste, and lost profit opportunities. With the addition of financial management, the income going to the school and program participants also increases. They gain experience in real decision-making, identifying and measuring inefficiencies in the system, calculating internal feed costs, and determining the profitability of the program. This is how a microenterprise should be run. Quote needed.

Although potentially hazardous, this waste also has economic potential as organic waste. Referring to the principles of circular economy, this program seeks to optimize this waste and potentially generate profits (Fitriastuti et al., 2023; Geissdoerfer et al., 2017). 3. The circular economy and the value of transforming waste larvae into feed pellets will complement efforts to reduce waste diversion (Morelli et al., 2024). Entrepreneurs Morelli et al. explain the sustainability of circular economy principles in business, while Morelli et al. are pursuing initiatives around schools. Participants synthesize business and waste management to create opportunities for transforming waste into fuel while supporting business sustainability on a large scale.

This program is designed to help participants build and develop various skills that are ultimately assessed through competency tests and are part of practical evaluations both before and after the program. There are also other technical skills acquired such as larval pellet production, feed formulation, feed drying, and feed extrusion. Managerial skills are also acquired and are equally important in organizing and production, stock recording, and cashiering. There is a sense of entrepreneurial satisfaction, albeit small, that helps in meeting needs. Driven by Rae, (2006); Salam et al., (2023) changes in entrepreneurial intent among student santri, mainly as a result of access to financial literacy, which shows the impact of entrepreneurial education. Students demonstrate competence in record-keeping through simple income and expenditure reports, cost estimates and projections, and sufficient profit margins that can be implemented (Sari et al., 2022).. These elements demonstrate business viability, assist in production planning, and enable evidence-based decision-making regarding pricing, identifying target markets, and control.

The increased value of downstream processing after the initiatives economic impact would be the value of the finished product would rise from treated pellets from rp 5,000/kg to rp 12,000/kg cost saving from active inputs is always encouraged to be brought to balance with appropriate cost tracking in value added processing this is important in establishing cost efficiency and impact of changes made on value added processing. Outcomes of (Tschirley et al., 2015) clearly show product improvement with proper value chain adjustments will help establish competitive rural enterprises.

Similar to the other examples already described, the student-run manufacturing unit represents social entrepreneurship by the integration of social, economic and educational objectives (Dzikrulloh et al., 2023; Mair & Martí, 2006). Social entrepreneurship aims to develop and distribute positive economic value, and sustainable business entails financial literacy and the efficient allocation of resources, the rational planning of integrated investments, and the profitability of long-term business viability. Therefore, learning to manage and control a business means that students understand the economic impact of their technical work and its value to society.

Teaching students vital social competencies was also made possible by the initiative. Students took on leadership positions, a culture of orderly management was developed, and the institution's productive potential was improved. This was due to the students and managers being empowered to monitor and control flows of economic activities and the resources for a given period of time, as well as to streamline the production and marketing of selected products. This

is in line with the concepts of community-based economic development where social capital, leadership, and empowered institutions are as important as profit (Peredo & Chrisman, 2006)

Some outcomes align closely with the Sustainable Development Goals (SDGs). The development of various types of animal feed through BSF-based production directly contributes to SDG 2 (Zero Hunger) by strengthening local food security. The availability of consistent, nutrient-rich feed supports healthier livestock growth and reduces the community's dependence on external commercial feed, thereby ensuring a more stable and sustainable food system. At the same time, entrepreneurial activities emerging from pellet production create pathways for income generation, savings, and financial empowerment among students and managers. These outcomes embody SDG 8 (Decent Work and Economic Growth) by introducing practical financial literacy, real market engagement, and responsible income management within an educational and community-based setting. Moreover, the program demonstrates a clear alignment with SDG 12 (Responsible Consumption and Production) through the conversion of organic waste into valuable feed products. This circular economy-based approach reduces waste accumulation, enhances resource efficiency, and introduces environmentally sound production methods that reflect global sustainability principles (Aizat Jamaludin et al., 2023; Gandhi et al., 2024).

In addition to these dimensions, SDG 8 emphasizes the crucial role of systematic record-keeping as part of inclusive and sustainable economic growth. Through structured financial documentation, students and managers learn to monitor cash flow, track profitability, assess operational efficiencies, and identify potential areas for business expansion. The adoption of these practices strengthens the reliability and accountability of the enterprise, enabling evidence-based decision-making that enhances long-term sustainability. Proper record management also improves resource use efficiency by ensuring that inputs, outputs, and production costs are accurately measured, thereby preventing financial leakages and operational waste. These competencies bridge micro-level business management with macro-level development goals, as transparent financial systems support economic resilience, strengthen institutional capacity, and contribute to broader community development outcomes.

Sustainable program development will be supported by improvements in innovative development, digital technology, and quality market share. Automation of analysis and management reports, digital financial business exports, and business process analytics enable financial technology to achieve profits within the deadline set by Nambisan in 2017. Used with the right framework, cross-sector partnerships involving universities, as well as the public and private sectors, can provide sustainability for the collaborative system governance structure for joint partnerships designed to enhance project initiatives (Sintasari et al., 2025)

Program innovations in BSF-based feed systems and community-based entrepreneurship constitute a significant part of the integration of production, management, and financial components as described in section 3.3 of the BSF-based feed innovation manual. A half-mistake, comprehensive documentation, facilitates the perfection of the administrative processes underlying operational control, fund flow iii, and management control as discussed earlier. Proper integration between finance and guidance, with production, will increase the output of economic activities across the inter-institutional and inter-institutional performance economic framework. More fundamentally, it resolves social and ecological issues. The distinctive attribute of this approach is the application of circular economy principles on the entrepreneurship and financial management education provided. This can be used as a model for community-based organizations striving to achieve social, economic, and ecological benefits.

CONCLUSIONS

Based on the previous staff role, the objectives of the community service program offered by An-Nur Ngrukem Islamic Boarding School were finally achieved on the improvement of downstream BSF maggot product processing, increasing the maintenance of the production capacity, and enhancing the management skills acquired in the community service program. Through socialization, training, technological application, and mentoring, the partner institutions successfully transformed fresh maggots to more shelf-stable, economically valuable, and marketable feed pellets. Indicators of success included, measurable improvement of the technical and managerial skills of the participants from pre and post evaluation, an increase of product

value from Rp 5.000/kg fresh to Rp 12.000/kg pellets, and the establishment of a student managed production unit which institutionalized the business processes within the pesantren. This indicates the program success was achieved on the environmental and socio-economic benefits.

During the evaluation, gaps in the knowledge of partners about feed formulation, production management, and an over dependence on automation which was recently introduced was difficulty encountered. However, continuous mentoring, participatory evaluation, and a sustained approach to them, showed improvement in technical and managerial discipline. The showcased innovative practices of the program focusing on waste-to-feed practices for pesantren demonstrates the creation of a safe, self-reliant business model, thereby reducing risk of oversupply and creating business income diversification. Furthermore, the program theorizes new evidence on the integration of community-based micro-scale agribusiness development along the circular economy. Additionally, community-based enterprises and the integrating circular economy frameworks with micro-scale agribusiness development provides community-based enterprises a proof of concept for similar educational institutions to replicate.

The program fulfills the Sustainable Development Goals (SDG) (SDG) 2 (Zero Hunger) by offering alternative sustainable sources of feed, SDG 8 (Decent Work and Economic Growth) by generating new entrepreneurial opportunities, and SDG 12 (Responsible Consumption and Production) by closing the loop on organic waste through circular economy practices. Future programs should emphasize the systematic management of community-owned digital production, advanced training on feed nutrition and business management, and off-community market expansion strategies. For Ensuring impact and scale, strategic partnerships with academic institutions and the public and private sector will be needed.

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Sponsorship emerged from the unity and cohesion of community constituents and members, creating a community spirit that shaped the program's goals. Each stakeholder's contribution and the entrepreneurial spirit of the Islamic boarding schools working within a circular economy social sponsorship interwoven innovation provided a foundational social focus which was strengthened by the social and adjacent skills for sustained adaptive divergence. Their collaborative spirit allowed successful innovation and initiative to be delivered. The community members sponsored the program and built the required spirit for its execution.

ETHICAL CONSIDERATIONS

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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