



Minimum Viable Product (MVP) Documentation

**BSF based aquaculture feed
for African catfish fingerlings**

Living Lab NUSL



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1. Overview

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Location: Njala University

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1.1. Abstract

This MVP constitutes a simplified yet scientifically rigorous aquaculture system designed to assess the efficacy of Black Soldier Fly (*Hermetia illucens*) larval meal as a sustainable alternative protein source to conventional fishmeal in the diet of African catfish (*Clarias gariepinus*) fingerlings. The system integrates locally sourced BSF biomass with cost-effective, standardized rearing materials to enable precise evaluation of key performance indicators including specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), hematological parameters (e.g., white blood cell counts, lymphocyte levels), and condition factor (K). Conducted under controlled environmental conditions, this MVP minimizes initial capital and operational costs while generating robust data to inform feed formulation optimization and support scalable, eco-friendly aquaculture production models.

The development of Black Soldier Fly (BSF) fish feed at the Njala University Living Lab holds substantial potential for fish farmers in Sierra Leone. This advancement is a targeted initiative aimed at tackling one of the nation's ongoing aquaculture hurdles, limited access to feed and its high costs. Feed is the primary constraint on the growth and advancement of aquaculture in Sierra Leone, making the implementation of BSF meal a timely and strategic response. Within the Living Lab, BSF meal has been successfully utilized as a partial substitute for both fishmeal and soybean meal in the diet of *Clarias gariepinus* (African catfish), with inclusion levels capped at 25 percent. The production of BSF meal is straightforward, economical, and easily adoptable by farmers. The process starts with capturing adult flies using appropriate decaying attractants to harvest eggs, which subsequently hatch into larvae. These larvae can be cultivated in affordable, locally sourced containers filled with organic waste, or in more sophisticated BSF breeding setups for large-scale production. Common organic waste materials used for BSF maggot production in the LL include vegetable leftovers, cassava skins, poultry droppings, pig manure, agricultural by-products, household refuse, and waste from restaurants. It is important to mention that BSF maggot production can be conducted anywhere and by anyone, making it especially appropriate for urban and peri-urban settings as an effective method of converting waste into resources. BSF maggots are collected after approximately 14 days and then dried, either through sunlight or using an oven, before they are ground into meal. Adequate processing guarantees that the final product is clean, dry, finely milled, and nutritionally rich. The meal is stored in sealed containers to maintain its freshness. The Living Lab has demonstrated impressive feed conversion ratios (0.6–0.8) when using BSF meal as a partial alternative to traditional protein sources. Notable advantages include lower feed expenses, reduced dependence on imported fishmeal, enhanced fish growth and feed efficiency, and improved environmental sustainability through the recycling of organic waste. This ready-to-use innovation offers farmers a practical, cost-effective route to achieving more profitable and resilient aquaculture in Sierra Leone.

1.2. Photos



Figure 1: BSF feed production

1.3. Motivation and challenges tackled

Motivation

This project was motivated by the urgent need to make fish farming more affordable, sustainable, and accessible especially for small-scale farmers in developing countries like Sierra Leone. The high cost of fishmeal, which is commonly used in fish feed, makes it difficult for farmers to maintain profitable operations. At the same time, fishmeal production harms the environment through overfishing and unsustainable practices and this has been a serious for years.

The researcher was particularly driven by the potential of Black Soldier Fly (BSF) larvae as a local, low-cost, and eco-friendly protein source. BSF larvae can feed on variety organic wastes such as food scraps and agricultural by-products and convert it into protein-rich biomass. This not only helps reduce feed costs but also supports waste recycling and environmental protection, aligning with circular economy principles.

Challenges Tackled

In Sierra Leone, many small-scale fish farmers ultimately struggle with the high cost of commercial fish feed which are basically imported from neighboring countries. This issue has been for decades affecting the growth of the aquaculture sector nationwide. Besides, quality feed is often too expensive or hard to access, making it difficult for farmers to run successful operations.

There has also been limited research on the use alternatives particularly Black Soldier Fly (BSF) meal as a replacement for fishmeal, especially in African catfish farming. Therefore, more information is needed on how BSF feed affects fish growth, health, and feed efficiency. In addition, traditional fishmeal production raises serious environmental concerns. It contributes to overfishing and pollution,

while large amounts of organic waste from households and farms are often thrown away instead of reused.

This project helps address these issues by testing BSF meal as a locally available, affordable, and environmentally friendly alternative. The goal is to make fish farming more sustainable and accessible, especially for small farmers who need low-cost, effective solutions.

1.4. Feedback process

The feedback mechanism was a pivotal aspect of the initiative, aimed at fostering ongoing communication between the Living Lab (LL) participants, mainly the lead laboratory technicians, and the Innovation Actor (research lead). This cooperative and application-focused strategy ensured that the intervention remained in sync with the real-world needs, priorities, and experiences of end-users. Initial discussions with fish farmers highlighted ongoing issues concerning the steep prices of commercial fish feed and the pressing demand for cost-effective, locally produced alternatives. This input played a crucial role in shaping the Minimum Viable Product (MVP), which centered on utilizing Black Soldier Fly (BSF) larvae meal as an economical protein replacement. BSF eggs were gathered using traps for fruit and vegetable waste around Njala University, while supplementary feed components were sourced from local markets based on their availability and cost-effectiveness. This strategy guaranteed that the feed solution was nutritionally suitable, economically viable, and scalable for smallholder aquaculture systems. During the implementation phase, LL participants were consistently involved through organized discussion. The Innovation Actor offered ongoing support regarding feeding methods, water quality management, and the performance of African catfish (*Clarias gariepinus*) on the BSF-based diet. These interactions facilitated real-time modifications to feeding schedules and enhanced the practical applicability of the innovation. Upon concluding the implementation cycle, the Innovation Actor delivered a detailed feedback report to supervisors and senior academic reviewers. The session featured well-organized presentation materials, including clear summaries and visual charts that depicted performance results. Supervisor feedback centered on the operational viability, potential cost savings, and sustainability benefits associated with incorporating BSF meal into fish feed formulations. They also noted aspects for improved ingredient sourcing, formulation consistency, and broader adoption strategies. This constructive feedback will aid in further refining the MVP and shape the planning of upcoming pilot rollouts and scaling strategies. Overall, the iterative, reciprocal feedback process reinforced the initiative by merging scientific evidence with local knowledge, ensuring that the BSF-based innovation is both technically robust and practically applicable within the context of Sierra Leonean aquaculture.

2. Implementation

2.1. MVP Design

2.1.1. Key Components

This section outlines the main materials and tools used in the study, including the fish tanks, diet formulations with varying BSF levels, water quality monitoring instruments, and methods for tracking fish growth and health.

- **Fish Tanks:** Transparent plastic troughs were used to hold the African catfish fingerlings, allowing easy monitoring and management.

- **Diet Formulation:** Feeds were prepared with varying levels of Black Soldier Fly (BSF) larvae meal comprising 0%, 10%, 15%, 20%, and 25% to test the effects of gradually replacing traditional fishmeal.
- **Water Quality Monitoring Tools:** Equipment such as pH meters, dissolved oxygen (DO) meters, and thermometers were used to regularly measure key water parameters, ensuring a healthy aquatic environment.
- **Growth and Health Monitoring:** Regular tracking of fish body weight, length, and feed intake was performed, along with blood sampling for hematological tests to evaluate fish health and nutritional status.

2.1.2. Design Decisions

- **Incremental Fishmeal Replacement:** The feeding strategy focused on gradually substituting fishmeal with BSF meal to identify the safe and effective inclusion level without negatively impacting fish growth.
- **Simplicity and Accessibility:** The setup and procedures were designed to be straightforward and affordable, making them suitable for adoption in rural or resource-limited settings.
- **Iterative Feed Adjustments:** Feed formulations were continuously refined based on data collected from fish growth performance and health indicators, ensuring ongoing improvement of the diet.

2.2. Operations

Feeding Schedule: The experimental fish were fed twice a day, at 10:00 a.m. and 4:00 p.m., using a feeding rate of 0.5% of their body weight. This approach was designed to support healthy growth while reducing feed waste. A strict feeding schedule was maintained to ensure consistency and promote stable growth throughout the study.

Monitoring Fish Growth: Fish growth was monitored regularly to track performance. Body weight and length (both total and standard length) were measured **every** two weeks, while general observations were made daily. These measurements helped assess the effectiveness of the diets and overall health of the fish during the experiment.

Hematological Assessments: Hematological tests were conducted to assess the **physiological condition and overall health** of the fish, helping determine the **nutritional effectiveness** of the experimental diets. Blood samples were taken from **Clarias gariepinus** fingerlings to observe their responses to different feed formulations. An anticoagulant (EDTA) was used during sampling to prevent clotting and maintain the **integrity of blood cells**, ensuring accurate and consistent test results.

Water Quality Control: Maintaining optimal water quality was a key part of the experiment to ensure the health and growth of the catfish fingerlings. Water in the tanks was renewed every three days to prevent the buildup of waste and harmful substances. Additionally, uneaten feed was removed after each feeding to reduce the organic load, which can lead to poor water conditions if left unchecked.

Daily monitoring of important water parameters including temperature, dissolved oxygen (DO), pH, and ammonia levels was carried out using digital water quality meters. Regular checks allowed for

quick corrective actions when needed, helping to prevent stress, disease outbreaks, and other environmental issues. These measures ensured a stable and healthy environment suitable for consistent fish development throughout the trial period.

2.3. Bill of materials

Table 1. Bill of materials

Item	Quantity*	Unit cost	Total cost
African Catfish Fingerlings	165 pcs	0.22	36.3
Rice bran	5 bags	4.4	22
45 liters plastic troughs	15	12	180
Eggies	45	0.4	18
Soybean meal	5 kg	0.45	2.25
Fish meal	5 kg	4.05	20.25
Vitamin premix	2 kg	3.52	7.04
Lysine	1 kg	2.75	2.75
Methionine	1 kg	3.69	3.69
Ascorbic acids	1 kg	8.93	8.93
Limestone	1 kg	4.4	4.4
BSF Trapping trough	1	44	44
Larva rearing trays	20	4.4	88
BSF unit construction	lump	1429.2	1429.2
Bulk tank	lump	132	132
BSF racks	2	173.7	347.39

2.4. Tools required

Table 2: Tools required

Item	Quantity	Unit cost	Total cost (SLE)
Digital Weighing Scale	Lump	200.5	200.5
Test strips	1	48	48
Hygrometer			
Feed Mixer	1	120	120
Blood Collection Tools	2 set	44	88
Measuring board		10.4	10.4
Disposable hand gloves	2	12	24
Plastic scoops	5	2.8	14
Transparent ruler	2	1.2	2.4
Working table	1	36	36

3. Economics

3.1. Business model

The main business idea behind this MVP is to provide a low-cost, high-protein fish feed by replacing traditional fishmeal with Black Soldier Fly (BSF) larvae meal, a more sustainable and locally available alternative. The feed is designed for smallholder fish farmers, helping them reduce production expenses while still achieving healthy fish growth and good performance.

This model encourages the development of local BSF farming by turning organic waste into insect protein, supporting a circular economy. It creates a system that not only improves fish farming but also contributes to income generation, waste reduction, and food security.

As outlined in Work Package 3 (WP3), the business model includes:

- Local feed production: Using simple tools and locally available materials to make the feed more accessible and affordable.
- Collaboration with BSF producers: Building partnerships with small-scale BSF farmers to ensure a steady supply of insect meal.
- Flexible distribution: Selling the feed through farmer cooperatives, agro-dealers, or direct-to-farmer channels to reach rural markets.
- Training and outreach: Running training sessions and awareness programs to help farmers understand the benefits of BSF-based feed and how to use it effectively.

4. Future improvements

4.1. SWOT analysis

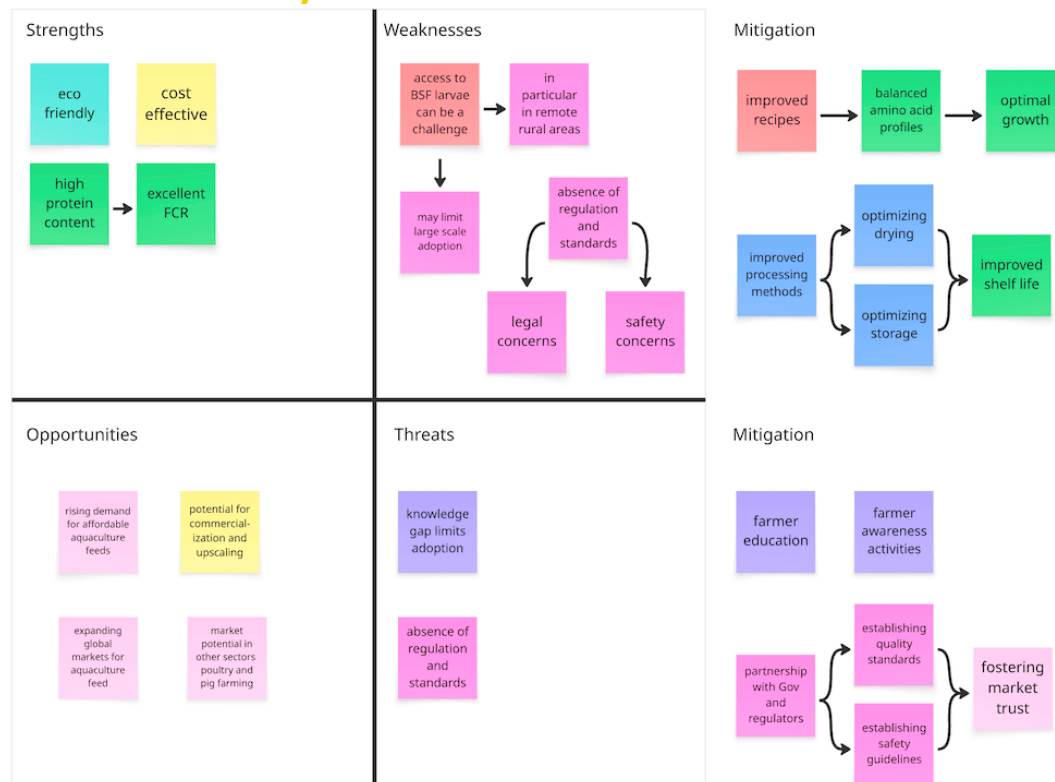


Figure 2: SWOT – NUSL LL – BSF based fish meal for African catfish fingerlings

Strengths

- The feed is eco-friendly
- The feed is cost-effective
- The feed supports better fish growth due to its high protein content from BSF meal
- It also contributes to waste reduction by converting organic waste into useful feed.

Weaknesses

- Access to BSF larvae can be a challenge, especially in remote or rural areas where insect farming is not yet established. This may limit large-scale adoption.
- Slow adoption. In addition, the absence of clear regulations or standards for insect-based feed may pose legal or safety concerns.

4.2. Optimization strategies

Feed Formulation Enhancement: Further improvements in the feed recipe can help balance amino acid profiles, ensuring fingerlings receive all essential nutrients for optimal growth.

Better Processing Methods: Upgrading the drying and storage techniques for BSF larvae can improve **feed shelf life**, reduce spoilage, and maintain nutritional quality over time.

4.3. Threat mitigation measures

Farmer Education and Awareness: Organizing training programs and demonstration projects can help educate farmers on the benefits, safety, and effectiveness of BSF-based feeds, reducing resistance and encouraging adoption.

Policy and Regulatory Engagement: Building partnerships with government agencies and regulators can help establish quality standards and safety guidelines, ensuring the feed is accepted and trusted in the market.

5. Appendices

5.1. References to experiments

An article is being prepared for publication in international journal for wider readership and feedback. However, the expectations of actors who are aware of the innovation is huge, because the outcome of this innovation will in no small measure impact aquaculture development in Sierra Leone.

Table 3. Growth performance, feed utilization, and condition factor of fish under different dietary treatments

Treat-ment	Weight Gain (g)	Mean Weight Gain (%)	Specific Growth Rate (SGR, %/day)	Daily Growth Rate (DGR, g/day)	Total Feed Intake (g)	Feed Conversion Ratio (FCR)	Pro-tein In-take (g)	Protein Effi-ciency Ratio (PER)	Condi-tion Factor (K)
TR.1	4.28	57.45	0.42	0.09	376.6	0.6	11.6	0.7	0.87
TR.2	5.87	77.14	0.52	0.12	410.7	0.6	12.0	0.5	0.85
TR.3	6.12	81.38	0.53	0.13	379.2	0.7	11.0	0.3	0.96
TR.4	6.73	92.81	0.58	0.14	430.3	0.8	13.0	0.9	0.92
TR.5	7.91	95.30	0.60	0.16	490.0	0.8	14.0	0.9	0.97

5.2. Additional Photographs/Documentation



Figure 3: BSF eggs on wood



Figure 4: BSF larvae in feeding trough



Figure 5: Innovation Actor performing lab work



Figure 6: Weighing BSF larvae harvest yield



Figure 7: Lab work with fingerling feeding trial setup in the background



Figure 8: fingerling feeding trial setup



Figure 9: Granulated pellets with BSF meal

5.3. Additional Notes

1. Product Name: BSF-Based Nutritional Feed Prototype for African Catfish Fingerlings

2. Description

This MVP is a specially formulated fish feed designed for African catfish (*Clarias gariepinus*) fingerlings, using Black Soldier Fly (BSF) larvae meal as a sustainable, high-protein substitute for conventional fishmeal. Developed through structured experimental trials, the feed prototype was evaluated for its impact on growth performance, feed efficiency, blood health parameters, and overall fish condition. Trials were conducted in controlled tank environments to test various inclusion levels of BSF meal and assess both biological outcomes and economic viability.

3. Purpose and Relevance

The primary aim of this feed prototype is to reduce the aquaculture sector's reliance on fishmeal, which is increasingly expensive and environmentally unsustainable. By incorporating insect protein from BSF larvae, the project offers a practical and affordable solution that aligns with the needs of smallholder fish farmers. This approach also contributes to circular economy practices by converting local organic waste into valuable insect protein, supporting environmentally responsible aquaculture, improving livelihoods, and contributing to food and nutritional security in low- and middle-income regions particularly Sierra Leone.

4. Key Features / Components

BSF Inclusion Levels: The feed includes BSF larvae meal at five levels including 0%, 10%, 15%, 20%, and 25% respectively to evaluate optimal performance.

Balanced Nutrition: The feed is formulated to meet the specific protein, energy, and micronutrient needs of catfish fingerlings, ensuring healthy growth.

Locally Scalable Production: Designed to be produced with readily available raw materials and simple equipment, enabling adoption by local feed producers or farmer cooperatives.

Performance Monitoring: Continuous data collection was conducted on fish growth rates, feed conversion ratios (FCR), and hematological responses to assess fish health.

Cost-Effective & Eco-Friendly: Reduces feed costs while promoting the recycling of organic waste into insect biomass through BSF farming.

5. Target Users / Beneficiaries:

- Small-scale fish farmers in search of affordable and sustainable feed options
- Aquaculture researchers and extension officers supporting innovation and farmer training
- Youth and women entrepreneurs exploring BSF farming as a livelihood opportunity
- NGOs and policy-makers focused on sustainable agriculture, circular economy, and rural development
- Academic and training institutions using the model for teaching and applied research

6. Methodology / Approach:

Experimental Design: Structured feeding trials conducted under controlled conditions to test feed with varying BSF inclusion levels

Growth Performance Monitoring: Weekly tracking of fish length, weight, and feed consumption to calculate growth rates and FCR

Hematological Analysis: Blood samples collected and analyzed for Red Blood Cells (RBC), White Blood Cells (WBC), and hemoglobin levels to assess fish health

Feed Composition Testing: Laboratory analysis to determine, fat crude protein, ash, and other nutrient levels of each feed formulation

Data Analysis: Statistical tools used to interpret the effects of different BSF levels on fish growth, health, and feed cost-effectiveness

7. Outcomes / Impact:

- Optimal BSF inclusion (50%) resulted in the best balance between growth performance and cost savings
- Significant reduction in feed costs by replacing fishmeal with locally sourced BSF meal
- Demonstrated effectiveness of insect-based feeds in controlled aquaculture environments
- Increased knowledge and acceptance among farmers, researchers, and stakeholders regarding alternative protein sources
- Environmental benefit through organic waste reduction and its conversion into high-value feed ingredients

8. Sustainability / Scalability Potential:

Environmentally Sustainable: BSF larvae can be raised on household and agro-industrial organic waste, lowering waste disposal issues and reducing environmental pressure from fishmeal production

Locally Scalable: Feed production methods can be easily replicated across rural and peri-urban areas using small feed mills or cooperative models

Value Chain Integration: Opportunities for establishing local supply chains connecting BSF producers with fish feed manufacturers and farmers, supporting local economies and job creation

9. Link to Project Goals:

- This MVP strongly aligns with the project's broader objectives to support innovative, sustainable aquaculture practices by:
- Promoting circular economy through "waste-to-feed" strategies
- Enhancing nutrition security by making fish farming more viable and productive
- Reducing environmental impacts by minimizing use of marine-sourced fishmeal
- Supporting capacity building through on-ground trials, farmer training, and institutional collaboration