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Deliverable D2.4 - Policy recommendation on insect production technology and capacity building

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Abstract	This report synthesizes evidence on Black Soldier Fly larvae (BSFL) as a circular, locally producible feed for poultry and aquaculture in Eastern Africa. Farmer surveys show significant adoption intent, yet a substantial demand/supply gap persists. Scaling BSF bioconversion of organics can unlock significant GDP gains, jobs, and GHG reductions. NESTLER proposes an actionable policy package: regulatory clarity (species, substrates), product and frass standards, source-segregated waste governance, blended finance for MSMEs (micro-small and medium enterprices), hub-and-spoke infrastructure, public offtake to anchor demand, MRV for climate benefits, targeted extension and certification, regional harmonization, and robust biosecurity and traceability.

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Definitions, Acronyms and Abbreviations

BSF	Black Soldier Fly
BSFL	Black Soldier Fly Larvae
BSFLM	Black Soldier Fly Larvae Meal
CGE	Computable General Equilibrium
EU	European Union
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
WTP	Willingness to Pay

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Executive Summary

This deliverable sets out an actionable roadmap to scale Black Soldier Fly (BSF) farming as a circular bioeconomy solution in Eastern Africa, targeting poultry and aquaculture feed markets while valorising urban and peri-urban organic waste. Farmer surveys in Ethiopia, Kenya, and Rwanda show near-universal intention to adopt BSF larvae (BSFL) as feed—98% in Ethiopia and Kenya, 99% in Rwanda—with country-specific willingness-to-pay that can be competitive where local production lowers costs.

The market is currently under-served. Across the three countries, daily demand from surveyed producers exceeds 200 tonnes of BSFL meal, while supply is roughly 55 tonnes per day. This gap reflects early-stage industry structure (pilot-scale plants), fragmented regulation, and limited post-processing capacity—despite ample, suitable organics that could be converted into feed and frass fertilizer.

On the other hand, scale potential is significant. Using conservative conversion factors, available organics could yield ~0.47 million tonnes of larvae in Ethiopia, ~0.26 million tonnes in Kenya, and ~0.18 million tonnes in Rwanda if fully processed. Engineering reality favours hub-and-spoke architectures—pre-processing near waste sources feeding rearing hubs—paired with reliable low-temperature drying to stabilize product quality.

It should be underlined that economy-wide and climate co-benefits are significant. Dynamic CGE scenarios link full biowaste utilization via BSF to annual GDP gains of ~USD 20.8B (Ethiopia), ~USD 12.6B (Kenya), and ~USD 317M (Rwanda), alongside substantial employment: ~0.79M jobs in Kenya, ~0.49M in Ethiopia, and ~0.44M in Rwanda. Climate modelling indicates annual reductions of ~4.86 Mt CO_2e (Ethiopia), ~2.56 Mt CO_2e (Kenya), and ~1.53 Mt CO_2e (Rwanda) through avoided landfill emissions and partial substitution of fishmeal/soymeal.

The document concludes by proposing a policy package, which includes sequential steps:

- First, establish regulatory clarity: a positive list of permitted insect species, substrate rules, HACCP-style hygiene requirements across rearing/processing/transport, and a frass standard with processing parameters and contaminant limits.
- Second, reform waste governance to secure source-segregated organics under multi-year contracts with licensed BSF operators.
- Third, publish BSFL meal and frass quality specifications, accredit regional labs, and roll out a traceability mark to build market trust and enable trade.
- Fourth, crowd-in investment via blended finance for MSME equipment and integrated facilities, complemented by time-bound fiscal measures and public offtake to anchor demand.
- Fifth, prioritize fit-for-purpose infrastructure and logistics (hub-and-spoke pre-processing, drying/milling, streamlined siting and permits).
- Finally, scale extension, certification, and applied R&D on substrate optimization, process control, frass agronomy, and risk management, while developing MRV protocols so organics diversion and GHG benefits can access results-based climate finance.

We conclude that BSF in Eastern Africa is no longer a technical experiment but an organization challenge. With clear rules, clean substrates, credible quality, bankable logistics, and targeted finance, the region can convert abundant organics into reliable protein and organic fertilizer, unlocking measurable gains in competitiveness, jobs, and emissions reductions.

1 Introduction

Rapid growth in poultry and aquaculture across Eastern Africa has intensified demand for affordable, high-quality protein feeds, even as traditional inputs such as fishmeal and soybean meal remain costly, volatile, and import dependent. At the same time, cities and agro-processing hubs generate large volumes of biodegradable residues whose disposal imposes sanitation and climate costs. Black Soldier Fly (BSF) larvae production sits at the nexus of these challenges and opportunities: it converts organic by-products into a nutrient-dense feed ingredient and an organic fertilizer (frass), offering a practical pathway toward a circular bioeconomy that enhances competitiveness, reduces waste, and mitigates greenhouse gas emissions.

This deliverable evaluates the technical and economic case for scaling BSF in Ethiopia, Kenya, and Rwanda, and translates evidence into policy recommendations tailored to the region's operating realities. We combine primary data on adoption intent and willingness to pay (WTP) from structured surveys of poultry and aquaculture producers with market sizing of current demand and supply, estimates of production headroom based on available organics, and economy-wide scenario analysis of growth, employment, and emissions outcomes. The survey evidence indicates near-universal willingness to use BSF larvae as feed, conditional on reliable supply and price competitiveness, while market data reveal a persistent supply deficit relative to current demand—underscoring both readiness to adopt and the need for coordinated scale-up.

To quantify the system-level implications of scale, we map potential larvae output from country-specific biowaste streams and assess indirect value-chain effects using a dynamic computable general equilibrium (CGE) framework. This approach captures not only direct value added in insect rearing and processing, but also linked impacts in waste management, feed manufacturing, livestock production, and associated services. The modelling highlights material contributions to GDP, job creation, and emissions reduction under scenarios in which available organics are fully utilized via BSF bioconversion.

The report is organized as follows.

- Section 2 presents farmer intentions and WTP, situating BSF within prevailing feed choices.
- Section 3 quantifies demand–supply gap and explains structural barriers limiting current BSFL production across the three countries.
- Section 4 examines scale potential, from biowaste availability to indirect economy-wide and climate benefits.
- Section 5 documents capacity building and farmer/youth training in Kenya and Rwanda, scaling practical know-how.
- Section 6 translates evidence into a sequenced policy package on regulation, standards, waste, finance, logistics

Collectively, the findings position BSF as an organizing framework to convert abundant organics into reliable feed and fertilizer, while advancing national priorities in food security, jobs, and climate action.

2 Intention and Willingness to Pay for BSFL

To assess farmers' intention and Willingness To Pay (WTP) for Black Soldier Fly larvae (BSFL) as an alternative feed ingredient, structured surveys were conducted in **Ethiopia, Kenya, and Rwanda**. The survey covered 700 poultry farmers in Ethiopia, 214 poultry farmers in Rwanda, and 913 fish farmers and 813 poultry farmers in Kenya.

The findings reveal an **exceptionally high acceptance rate** of BSFL across all three countries (Figures 1 and 2). In Ethiopia and Kenya, **98%** of farmers expressed willingness to use BSFL in their feed systems, while in Rwanda the proportion was **99%**. Such high levels of intention confirm that farmers are eager to adopt BSFL as a fed option, provided it is made available at competitive prices and in sufficient quantities.

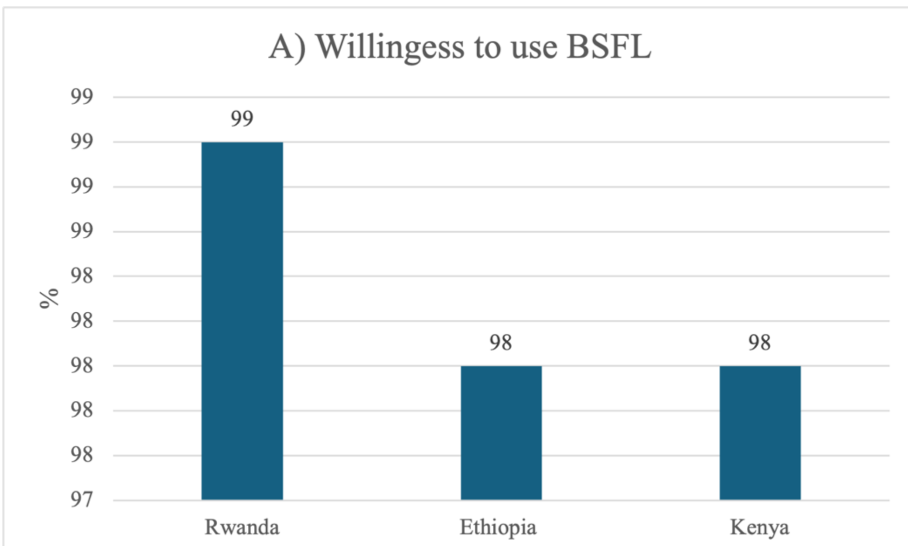

Figure 1: Willingness to use BSFL

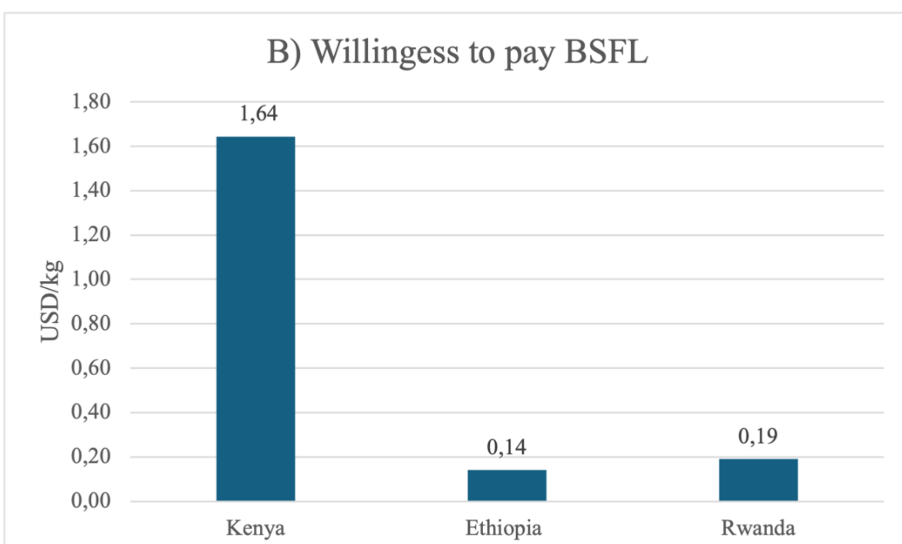

Figure 2: Willingness to pay for BSFL

2.1 Comparative Willingness to Pay

Within our survey, we also considered average WTP proposed by the farmers per BSFL kilogram (kg).

- In **Rwanda**, poultry farmers reported an average WTP of **USD 0.19/kg**, which is close to prevailing prices for conventional protein feeds.
- In **Ethiopia**, poultry farmers reported a lower WTP of **USD 0.14/kg**, compared to the average market price of conventional feeds at **USD 0.24/kg**.
- In **Kenya**, both poultry and fish farmers demonstrated strong interest, though their WTP reflected careful consideration of the balance between price competitiveness and performance outcomes of feeds.

These findings highlight that while BSFL adoption potential is **very high**, the WTP is **country-specific** and closely tied to prevailing market conditions for conventional feed.

2.2 Comparison with Conventional Feed Ingredients

Poultry and aquaculture sectors in Eastern Africa currently rely heavily on **fishmeal, soybean meal, maize bran, and sunflower cake** as protein and energy sources. Each of these has limitations that make BSFL an attractive substitute:

- **Fishmeal:** Widely used in aquaculture, but prices have risen sharply due to overfishing and declining wild stocks. In Eastern Africa, fishmeal can cost **USD 1.2–1.5/kg**, significantly higher than most farmers' WTP for BSFL. This creates a strong economic rationale for BSFL as a substitute, especially in aquaculture.
- **Soybean meal:** Imported in large quantities at prices between **USD 0.45–0.60/kg**. Price volatility, foreign exchange constraints, and competition with human food use limit its long-term sustainability.
- **Maize bran and other cereals:** Commonly used as energy feeds, with relatively low prices (**USD 0.15–0.25/kg**). However, they are poor in protein content (typically <12%), which makes them nutritionally inadequate for poultry and fish without supplementation.
- **Sunflower cake:** Regionally available but variable in quality, with protein levels lower than fishmeal or BSFL. Prices range between **USD 0.20–0.30/kg**.

Compared to these options, BSFL offers a **unique balance**:

- **Protein-rich** (40–60% crude protein, depending on processing).
- **High in essential amino acids**, closer to fishmeal than soybean meal.
- **Locally producible**, reducing dependency on imports.
- **Sustainable**, since it is derived from organic waste recycling rather than competing with food crops.

2.3 Why Farmers Would Select BSFL

Farmers' preference for BSFL over conventional feed proteins can be explained by three interlinked factors:

1. **Economic considerations:** While WTP is lower than current fishmeal and soybean meal prices, BSFL can significantly **reduce feed costs** if scaled, due to its local production potential. Unlike soybean and fishmeal, which are vulnerable to global market fluctuations, BSFL can be produced consistently at the community or national level.
2. **Nutritional advantages:** Unlike cereal-based feeds, BSFL provides **high-quality protein and lipids** essential for growth performance in poultry and fish. Numerous feeding trials have shown that partial replacement of fishmeal or soybean meal with BSFL maintains or even improves growth rates and feed conversion efficiency.
3. **Sustainability and resilience:** Farmers increasingly recognize the risks of relying on imported or unsustainably sourced ingredients. BSFL provides a **circular economy solution**, converting waste streams into valuable feed, while simultaneously reducing environmental footprints. This aligns with government and donor priorities on food security, climate action, and waste management.

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3 Current Demand for BSFL and Supply Gaps

The demand for Black Soldier Fly larvae (BSFL) in Eastern Africa is already substantial, particularly in the poultry and aquaculture sectors, where protein inputs account for a significant share of production costs. Data collected from Ethiopia, Kenya, and Rwanda point to a daily demand that exceeds **200 tonnes of BSFL meal** across surveyed farmers. In contrast, the region's current production capacity is estimated at just **55 tonnes per day** [2], underscoring a wide and persistent supply gap (Figure 3). This imbalance between demand and supply reflects both the rapid growth of animal production systems and the structural limitations that continue to hold back the insect farming sector. Poultry and fish farmers, especially those operating on small and medium scales, are increasingly aware of the nutritional and economic benefits of BSFL, and are prepared to integrate it into their feeding practices. However, the availability of BSFL meal remains far below what is required to satisfy even a fraction of the market's appetite.

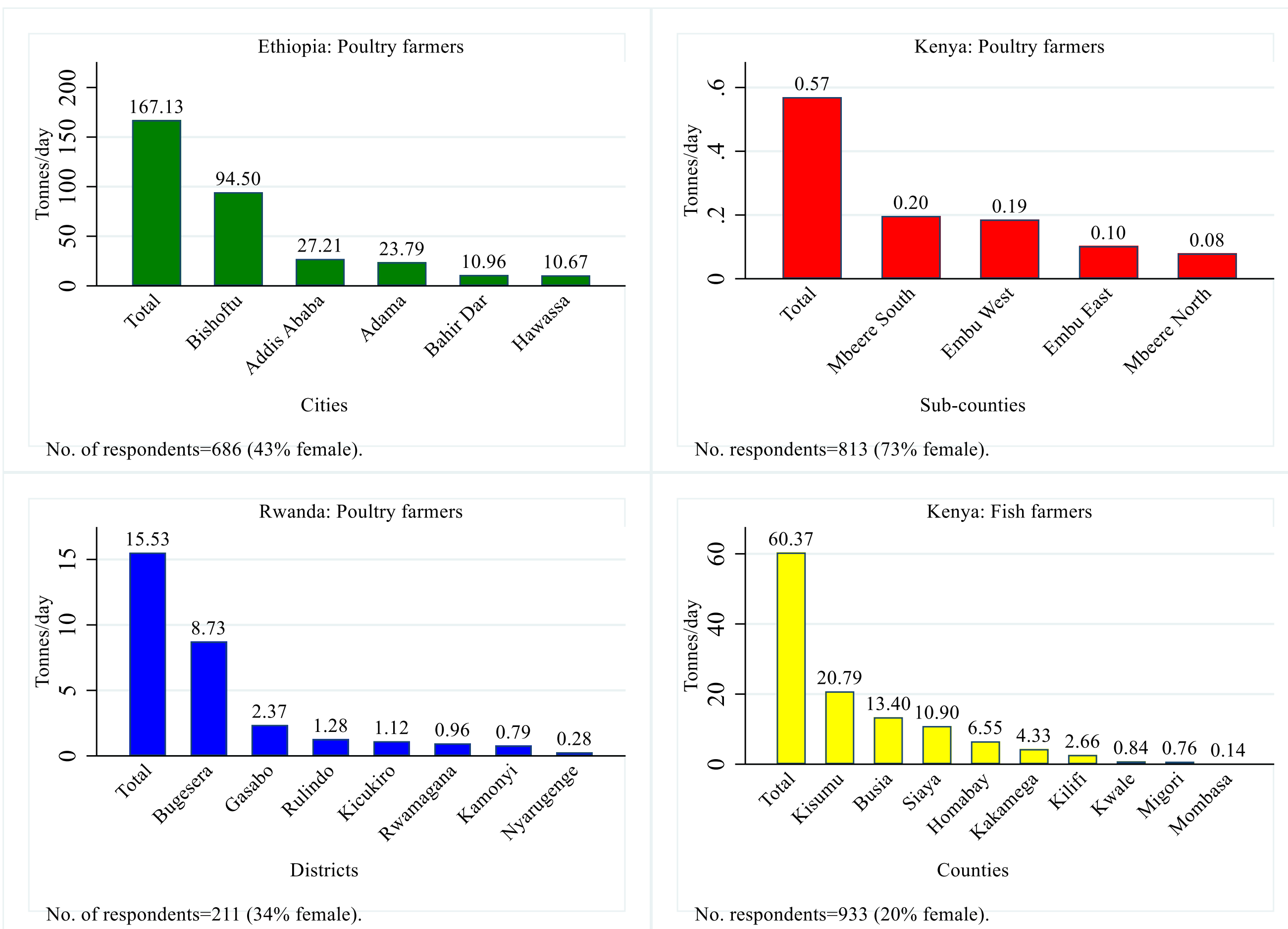

Figure 3: Market size for dried BSF larvae

The gap is shaped by several interrelated challenges. First, insect farming is still at a relatively early stage of development in the region. Most existing production facilities are pilot-scale ventures or small enterprises with limited capacity to process large volumes of organic waste into larvae meal. The technology for scaling BSF production, ranging from rearing systems to drying and milling infrastructure, is available but not yet widely adopted due to high upfront costs and limited access to credit.

Second, the regulatory environment remains fragmented. In several countries, national feed regulatory frameworks have not yet been fully updated to explicitly recognize insect-based proteins, creating uncertainty for investors and entrepreneurs.

Third, knowledge gaps persist among farmers, processors, and feed manufacturers regarding the handling, storage, and blending of BSFL with conventional feeds. These barriers collectively constrain the expansion of supply despite the strong market signals.

The result hides a contradiction: on the one hand, the region faces a critical shortage of affordable, high-quality protein feeds, driving up the costs of poultry and fish production. On the other hand, there is a readily available resource base in the form of organic waste that could be transformed into millions of tonnes of BSFL annually. Bridging this gap will require deliberate policy interventions, investment in infrastructure, and coordinated efforts to build technical capacity at all levels of the value chain.

If addressed strategically, the supply-demand imbalance presents not just a challenge but a powerful opportunity. By expanding BSFL production, Eastern Africa could simultaneously reduce dependence on costly imports of soybean meal and fishmeal, enhance the competitiveness of its poultry and aquaculture industries, and create a more sustainable, circular economy in which waste becomes a valuable input. As the evidence shows, the demand is already here. What is missing is the enabling environment to unlock supply at scale.

4 Potential of scaling BSFL

The scale-up potential of Black Soldier Fly (BSF) farming in Eastern Africa is anchored in two reinforcing dynamics. First, there is a sizeable, largely under-used stream of urban and peri-urban organics that can be valorised through larvae bioconversion. Second, the downstream markets, a.k.a. feed, organic fertilizers (frass), waste-management services, are expanding and policy-aligned. When these dynamics are coupled with sound biosecurity, product standards, and investment in fit-for-purpose infrastructure, BSF can transition from scattered pilots to an integrated circular bioeconomy segment with measurable contributions to growth, jobs, climate mitigation, and food systems resilience. The sections below quantify production headroom based on available biowaste and explain how wider economy-wide benefits emerge once scale effects take hold.

4.1 Potential BSFL Production

Figure 4 shows the relationship between total available biowaste and the potential production of BSFL in three East African countries [3]. Current estimates indicate that Ethiopia generates approximately **5.72 million tonnes** of biowaste annually, Kenya **3.19 million tonnes**, and Rwanda **2.18 million tonnes**. If fully processed with BSF, these streams could yield roughly **0.47 million tonnes**, **0.26 million tonnes**, and **0.18 million tonnes** of larvae, respectively. These are conservative point estimates that already illustrate the magnitude of the resource base and the feasibility of building a regionally significant insect-protein industry.

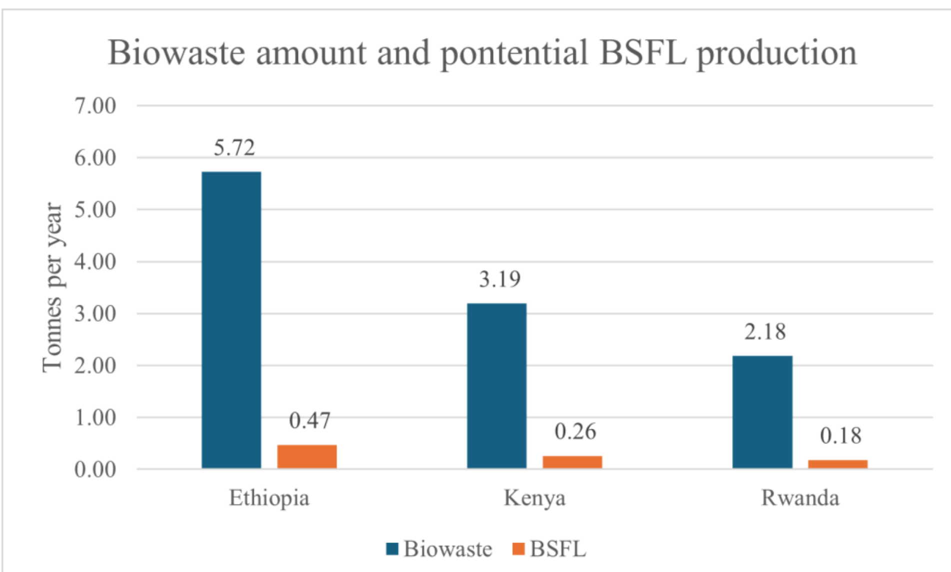

Figure 4: Potential biowaste utilization for BSFL production

From a process-engineering perspective, several factors control conversion of waste into insect biomass: substrate composition (protein/CHO/fibre), moisture and particle size, larval density, temperature and aeration, and pre-treatment (e.g., maceration or mild fermentation). Meta-analyses and controlled feeding trials report **bioconversion efficiencies** on a dry-matter basis that typically fall in the low-to-mid-teens and can exceed 20% under optimized diets, especially when substrates are balanced for protein-to-energy and the rearing environment is stabilized. These ranges are consistent with recent reviews and LCA-linked experiments that benchmark BSF performance across diverse agro-residues. [4] Nutrient end-products also matter for scale. Dried BSFL commonly contains **~41–65% crude protein** (processing-dependent) with an amino acid profile closer to fishmeal than plant meals, which underpins feed-mill substitution potential in poultry and aquaculture. Lipid fractions are co-products that can be rendered for energy or feed use, improving plant economics [5].

Realizing the headline production numbers requires basic but reliable infrastructure: segregated organics collection closer to source, HACCP-style rearing and harvesting units, and cost-effective drying/milling lines sized to local waste densities. Because larvae productivity is sensitive to ambient temperature and substrate freshness, distributed hub-and-spoke architectures that shorten transport times and buffer seasonality tend to outperform single, distant mega-sites in African urban geographies. Where cold chains are thin, modular dehydration (e.g., low-temperature continuous dryers) is essential to stabilize meal quality and suppress microbial risks before storage and transport to feed mills. Practical experience and regulatory guidance from other regions, e.g., EU hygiene guidelines for insects as feed and the evolving treatment standards for insect frass, can be adapted to East African contexts to speed safe scale-up [6]

4.2 Indirect Value Chain Benefits of Scaling BSFL Production

In addition to its direct role in protein feed production, the black soldier fly (BSF) farming value chain generates indirect benefits for other sectors of the economy because of its strong linkages with agriculture, waste management, and the feed industry. Quantifying these effects is complex, as BSF farming interacts with multiple pathways across sectors. To capture these wider impacts, we applied the International Food Policy Research Institute's dynamic computable general equilibrium (CGE) model [7]. Using scenario analysis, we assessed the potential outcomes if countries build sufficient capacity to utilize all available biowaste. Specifically, we quantified the contribution of BSF farming to economic growth, job creation, and greenhouse gas emission reductions.

4.2.1 GDP Gains

The macroeconomic signal from scaling BSF is large because the technology touches multiple markets: it displaces imported protein meals, injects value into waste streams, and stimulates local manufacturing and logistics. If all available biowaste were fully utilized for BSFL, the three countries could generate significant contributions to their economies (Figure 5). Ethiopia shows the largest potential GDP gain of about USD 20.8 billion annually, followed by Kenya with USD 12.6 billion, while Rwanda's contribution is much smaller at USD 317 million. These figures indicate that large economies with higher waste volumes, such as Ethiopia and Kenya, stand to capture substantial economic benefits from BSF farming, while smaller economies like Rwanda may still benefit but on a relatively modest scale.

The modelled gains are also consistent with broader literature on insects-for-feed and circular processing, which finds that when insect meals partially replace fishmeal and soybean meal, they reduce foreign exchange exposure and price volatility—two channels through which economy-wide benefits are transmitted in import-dependent feed markets [8].

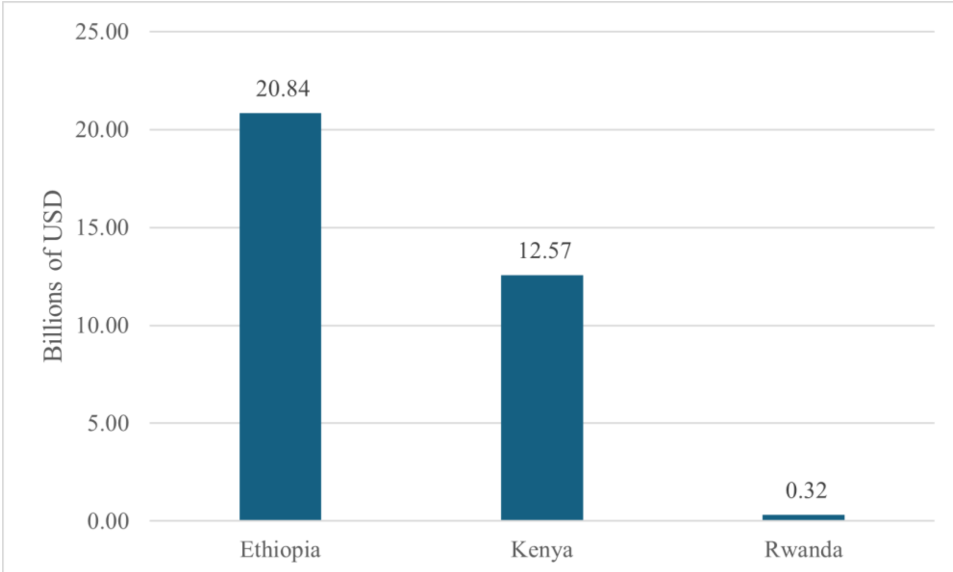

Figure 5: Economic growth contribution of scaling BSFL production

4.2.2 Job Creation

Employment effects arise at three layers: decentralized collection and pre-processing of organics; operation of rearing, harvesting, and post-processing units; and ancillary services (transport, quality testing, packaging, and distribution). Under the full-utilization scenario, Kenya shows the highest job potential at 790,000, followed by Ethiopia at 490,000 million, and Rwanda at 440,000 million (Figure 6). Importantly, these jobs are relatively place-based and can be seeded in secondary towns where underemployment is high, thereby supporting inclusive rural-urban linkages.

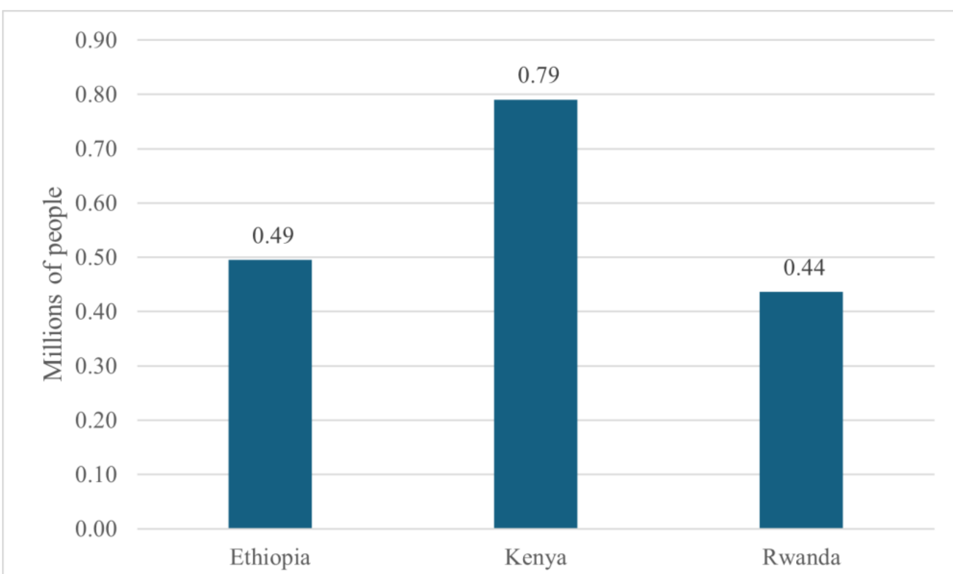

Figure 6: Job creation of scaling BSFL production

Because BSF units can be sized to local waste densities, job formation is **modular** and can scale with investment and policy support for MSMEs (Micro, Small and Medium Enterprises) and cooperatives. Unit economics tend to improve as facilities internalize more of the value chain (e.g., capturing both larvae meal and frass revenues) and as quality/traceability systems unlock access to the formal feed market. These structural features explain why modelled employment can be high even where aggregate GDP additions are modest.

4.2.3 GHG Emissions Reduction

In terms of climate benefits, Ethiopia leads with the potential to reduce 4.86 million tonnes of CO_2 equivalent annually if all biowaste is processed through BSF farming (see Figure 7). Kenya follows with 2.56 million tonnes, while Rwanda could achieve a reduction of 1.53 million tonnes. Although the absolute contribution varies, all three countries can generate important climate mitigation benefits, especially given that these reductions are achieved from a relatively small sector. These outcomes suggest that BSF farming can make meaningful contributions to national climate goals while simultaneously addressing waste management challenges.

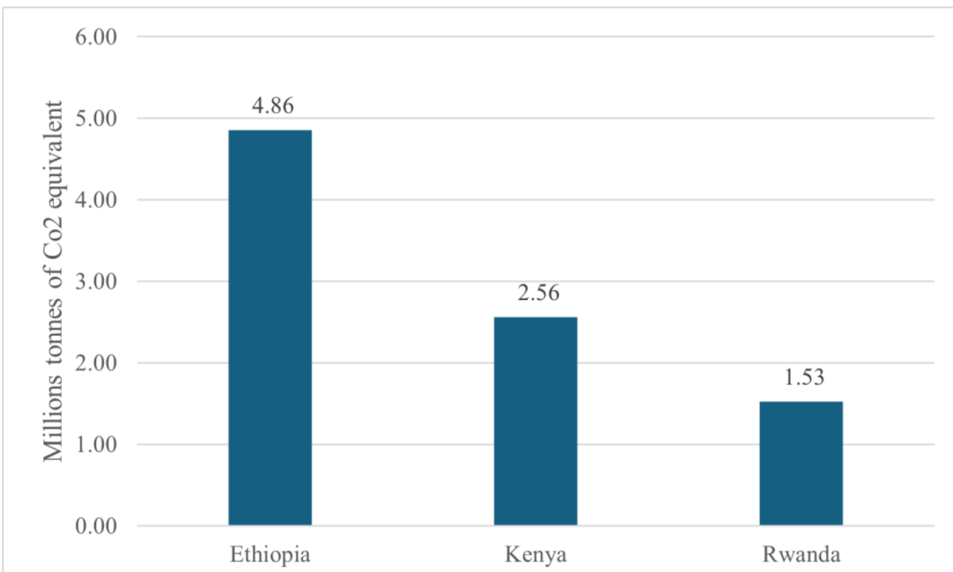

Figure 7: Greenhouse gas emissions reduction from scaling BSFL production

Multiple life-cycle assessments corroborate these climate advantages. Controlled comparisons show order-of-magnitude lower direct CO_2-equivalent emissions from BSF treatment relative to open windrow composting when measured on a per-tonne-waste basis, with one study reporting ~47× lower direct emissions under BSF treatment than composting in an Indonesian facility (with direct CH_4 and N_2O measured by gas chromatography). While results vary by substrate and system boundaries, the direction and magnitude of mitigation benefits are consistent across sites [9].

4.2.4 Food and Nutrition Security Effects of BSF Farming

Jensen et al. [5] integrated the Food and Agriculture Organization (FAO)'s FISH model with the Aglink-Cosimo model of global agricultural markets to assess the potential of insect farming in processing global food waste is projected to reach 2 billion tons by 2030. Their analysis indicates that utilizing this waste through insect farming could yield substantial quantities of insect meal and oil, with significant implications for food security. The partial equilibrium model predicts that insect farming could reduce protein feed prices by up to 30%, substitute up to 4% of conventional protein feed imports, and respectively increase the production of pork, poultry, and fish by 0.8%, 1.3%, and 0.3% by 2030

Similarly, country-level studies, highlight the potential food security benefits of insect farming through substitution effects and foreign exchange savings. Their research shows that processing one ton of biowaste through BSF larvae in Kenya can substitute soybean and fishmeal-based feeds. For each ton of biowaste processed, the substitution effect of replacing conventional protein feeds with insect-based feeds can provide sufficient nutrition to feed additional two people, based on current per capita consumption in Kenya.

One of the promising areas of food security in relation to insect farming is frass fertilizer. Previous studies have not fully explored its potential impact on food security at the macro or farmers' level. Given the current challenges in the global agrifood systems, it is essential to evaluate the effects of large-scale frass fertilizer production. Although comprehensive economic analysis is lacking, small-scale experimental studies have shown encouraging results (see Figure 8). The yield effects of frass fertilizer vary among crops. Successful introduction of frass fertilizer could therefore improve food security for adopting countries.

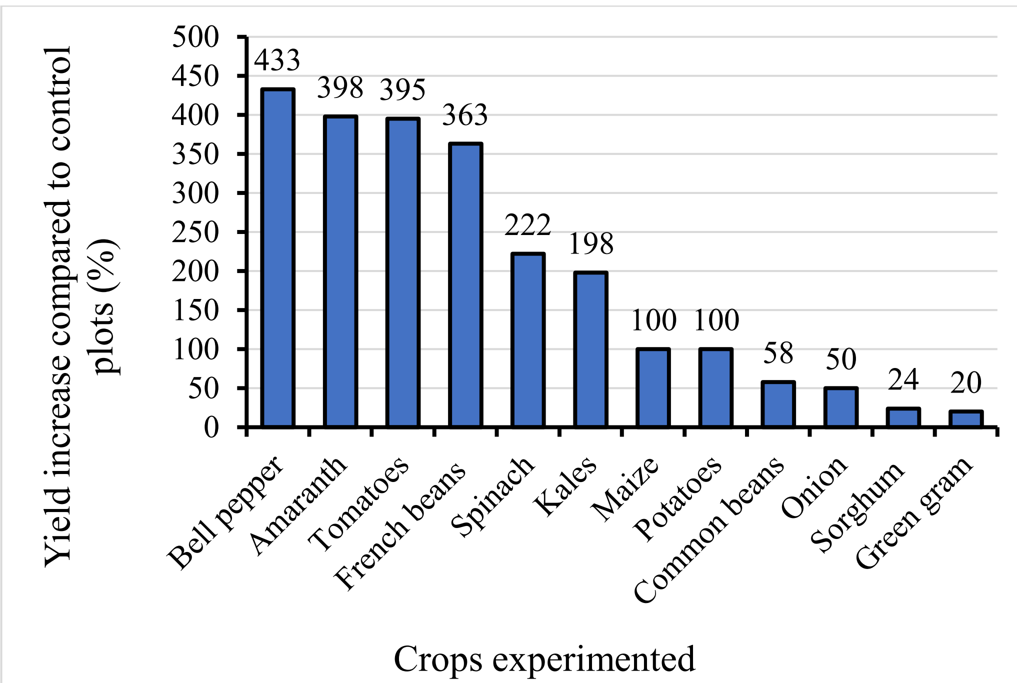

Figure 8: Yield impact of frass fertilizer compared to commercial organic and synthetic fertilizers [2]

A significant enabler is the regulatory pathway. While our focus countries are in Eastern Africa, international precedents accelerate domestic policy design. In the EU, lifting parts of the feed ban in 2021 expanded the legal use of insect proteins in several livestock categories; in the same period, baseline standards for placing insect frass on the market as an organic fertiliser were clarified and aligned with processed animal manure treatment rules. These steps, coupled with good-hygiene guidance for insect producers and ongoing work on allergenicity and fraud prevention, illustrate pragmatic regulatory sequencing that can be adapted—rather than copied—to local conditions.

5 Capacity Building

5.1 Farmers training in Kenya

NESTLER project has built capacity (soft and hard skills) of 1546 youths and women in Kenya (936 males and 610 females) through an Entrepreneurship incubation program established in ICIPE.

Moreover, the project has increased visibility of insect farming and currently the **First Lady of Kenya (Rachel Chebet Ruto)** has endorsed the scale up of insect farming under the "**Mama Doing Good**" initiative. Many other groups have benefited from this training program such as Caritus Muranga Fish Farmers, Korogocho youth group, Kenya Red Cross, Rainforest Alliance, DanChurchAid and others.

Figure 9: Group Photos of young entrepreneurs that have started their business in insect farming or using BSFL feeders based on NESTLER capacity building activities

5.2 Farmers training in Rwanda

Farmers participated in a training program on Black Soldier Fly (BSF) larvae farming, using Standard Operating Procedures (SOPs) developed under the NESTLER Project. Protein derived from Black Soldier Fly larvae meal has the potential to replace soybean or fish meal protein in aquaculture feed. A total of 100 farmers have been trained by RAB within 2024.

This training was highly significant, as it equipped the participating farmers with the skills needed to train others in their communities. The training program included both theoretical and practical components. The theoretical sessions were conducted in a classroom setting, while the practical sessions took place at a poultry site and the BSF Larvae Production Unit located in Rwanda. Each participant committed to training at least three additional individuals under the supervision of the NESTLER project staff, fostering knowledge dissemination across the community.

Figure 10: Group Photos of farmers training in Rwanda

6 Policy Recommendations

The evidence presented in this report shows that Eastern Africa stands at a pragmatic inflection point. Farmer surveys in Ethiopia, Kenya, and Rwanda indicate exceptionally high intention to adopt Black Soldier Fly (BSF) larvae as a feed ingredient, with willingness-to-pay. Market data point to a daily requirement that already exceeds 200 tonnes of BSFL meal, compared with a regional production capacity of roughly 55 tonnes/day, leaving a persistent gap that constrains poultry and aquaculture competitiveness. The policy task is therefore **not to prove the concept, but to organize it.** That means

a) building a regulatory pathway for producers and feed mills,
b) investing in the mundane but decisive infrastructure that moves organics and stabilizes meal quality
c) aligning finance so that SMEs and cooperatives can enter and grow and
d) hard-wiring measurement and standards so the sector is safe, bankable, and tradable across borders.

We believe that when the above actions are implemented, BSF will not be just another “alternative feed”, but a systems solution that simultaneously addresses waste, feed costs, farmer incomes, and urban sanitation, while contributing to national climate targets.

6.1 Regulatory clarity: creating a predictable “rules-of-the-game”

A foundational first step is regulatory clarity. International experience shows that predictable authorisations for insects as feed, and hygiene rules across the chain, unlock investment. The European Union provides a useful benchmark. In 2017, the EU authorised processed animal proteins derived from farmed insects in aquaculture (Regulation (EU) 2017/893), and in 2021 extended authorisation to poultry and pigs (Regulation (EU) 2021/1372). These acts sit within the broader animal by-products regime and specify species and hygiene conditions, signalling a coherent end-use framework to market actors [11] [12].

For **frass** (the organic residue from BSF rearing), Europe’s approach has been to align treatment and placing-on-the-market requirements with fertiliser legislation, notably the EU Fertilising Products Regulation (EU) 2019/1009, while producer organisations have issued practical guidance (e.g., time–temperature treatment such as 70 °C for one hour) to standardise safety expectations [13]. Though details vary by Member State, the trajectory is clear: treat frass as a distinct organic fertiliser category with defined processing parameters and labelling rules, thereby allowing trade and farmer confidence. These examples do not need to be copied wholesale; they illustrate sequencing and scope that Eastern African regulators can adapt.

NESTLER recommends that ministries responsible for livestock, feed safety, fertilisers, and waste jointly establish an **Insects-for-Feed and Fertiliser Regulation Track** with four immediate deliverables:

a. a **positive list** of permitted insect species for feed;
b. **substrate rules** that approve specific organic by-product categories and exclude risky streams;
c. **Good Hygiene Practice (GHP)/HACCP-style** requirements for rearing, processing, and transport

d. **frass standards** that set minimum processing, contaminant limits, nutrient declaration, and labelling.

This can be anchored to Codex-aligned frameworks, leveraging FAO guidance on how international standards reduce trade friction and increase compliance [8]. Clarity on **risk management** is equally important. Scientific opinions and risk profiles highlight potential hazards associated with insects as feed (microbiological risks, chemical contaminants, and allergenicity) most of which are controllable through substrate selection, thermal treatment, and traceability. Integrating these hazards into national guidance reduces uncertainty for producers and feed mills without imposing disproportionate burdens [14].

6.2 Waste governance policy: from "what to collect" to "how to move it"

No insect sector scales without steady, clean input streams. Urban and peri-urban organics governance is therefore core industrial policy. The paradox today is that countries generate large amounts of biowaste that impose sanitation and climate costs, while feed manufacturers struggle with high protein prices and volatility. Global assessments estimate that a **20% of food is wasted**, contributing **~8–10% of global GHG emissions**; those headlines translate into very local piles of fruit/vegetable trimmings, market leftovers, and food-service scraps that could feed BSF larvae every day. Designing collection to **harvest** that value is a policy choice, not a technological mystery [15].

Municipalities and counties can adopt **source-segregation** by ordinance, prioritising markets, food-service hubs, agro-processors, and institutional kitchens where homogeneous organic streams are easiest to secure. They can designate **insect-compatible transfer points** and publish tender frameworks that allow licensed BSF operators to contract for feedstocks on multi-year terms. Where formal collection is thin, **city–cooperative partnerships** can professionalise small haulers with training on contamination control, simple pre-processing (maceration, dewatering), and record-keeping so that inputs remain traceable. These governance steps reduce contamination risk upstream and lower the unit cost of feedstock, which is decisive for plant economics.

6.3 Quality assurance from day one: standards that build trust

A market for BSFL meal will mature only if feed mills and farmers trust the product. That trust rests on **quality specifications** and **verification**. Standardising a small set of attributes—moisture, crude protein, crude fat, ash, FFA in oil fractions; microbiological plate counts; and heavy metals—ensures that BSFL batches are predictable in formulation. National standards bodies, in consultation with feed millers' associations and universities, should publish a **BSFL meal specification** that references validated methods and sets **classification bands** (e.g., "Prime", "Standard") linked to price differentials. For frass, clarity on nutrient declaration (N-P-K), organic matter, potential contaminants, and the presence of chitin will support agronomic recommendations and farmer uptake.

To reduce compliance costs for MSMEs, regulators can accredit **regional laboratories** and allow **producer group testing** for batches aggregated under shared SOPs. Over time, a **traceability mark**—analogous to quality seals in other agro-industries—can differentiate compliant producers and ease cross-border trade once regional mutual recognition develops.

6.4 Finance and incentives: crowding-in capital where it matters

Scaling from 55 tonnes/day to orders of magnitude more requires capital at three layers: a) **working capital** for feedstock and operations, b) **equipment finance** for rearing, drying, and milling and c) **infrastructure finance** for organics logistics. Governments and development partners can lower the cost of capital with **blended instruments** (partial credit guarantees, first-loss tranches) targeted at **bankable unit operations**, not open-ended subsidies. Because the economics improve sharply when plants valorise both **larvae meal** and **frass**, early support should prioritise integrated facilities or co-location with composting and fertiliser blenders to realise full revenue stacks.

Tax policy can accelerate uptake without eroding the base. Temporary **accelerated depreciation** for insect-rearing and drying equipment, **VAT exemptions** on critical inputs, and **import-duty relief** for specialised machinery reduce up-front barriers during the scale-up window. Where climate or waste-management outcomes are contracted, **results-based payments** can be tied to verified tonnes of organics diverted from landfill or measured emissions reductions (see Section 5.8). These instruments should be time-bound and sunset as unit costs fall and markets mature.

6.5 Infrastructure and logistics: designing for reliability, not heroics

BSF production is sensitive to temperature, substrate freshness, and handling time. That means logistics are not an afterthought but part of the production function. The most resilient configuration in African urban geographies is a ***hub-and-spoke*** model: pre-processing nodes close to waste generation (for maceration and dewatering), with daily or sub-daily transfers to rearing hubs sized to local feedstock densities. Because cold chains are expensive, the policy goal is to **shorten time-to-larvae** rather than chill everything. Once harvested, **low-temperature continuous dryers** stabilise meal with minimal protein damage and suppress microbial risks. Finance facilities should explicitly cover these pieces of kit, while regulators should issue **permitting fast-tracks** for applicants who meet siting, biosecurity, and odour control criteria.

Transport rules also matter. Simple requirements on covered vehicles, clean-down protocols, and route times limit cross-contamination and nuisance. Municipalities can designate **priority time windows** for organics movement to avoid congestion and spoilage. All these recommendations may be realized by coordination and predictable permits.

6.6 Research, extension, and human capital

BSF farming succeeds where operational detail is mastered: a) **substrate recipes** balanced for protein and energy, b) **larval densities** and **batch timing** that avoid heat stress, c) **aeration** and **moisture** controls that limit moulds, and d) **post-processing** that locks in quality. A practical science agenda should therefore focus on **applied optimisation**, not only on new inventions. Priorities that NESTLER considers most important are:

a. feedstock mapping and seasonality models
b. performance benchmarking across common African substrates
c. LCA of alternative process configurations
d. frass characterisation and crop-specific response curves and
e. hazard mapping tied to substrate and process controls.

Producer training can then translate protocols into daily practice through extension curricula and certification short courses. Given the employment potential identified in our analysis **technical and entrepreneurial training** is not a social add-on but a production necessity. Skills programs should encompass **bioconversion operations**, **maintenance**, **quality control**, and **business management**, with explicit pathways for women and youth.

6.7 Environmental, LCA, and climate finance: measuring what matters

The climate case for BSF bioconversion is also very strong: diverting organics away from landfilling and unmanaged dumping reduces **methane and nitrous oxide**, and substituting part of fishmeal/soybean meal avoids upstream emissions. Our modelling estimates annual reductions of roughly 4.86 Mt CO_2e (Ethiopia), 2.56 Mt CO_2e (Kenya), and 1.53 Mt CO_2e (Rwanda) under full-utilisation scenarios. Embedding these gains into national climate plans requires **standardised MRV** (measurement, reporting, verification). Ministries of environment can convene a technical group to define **default factors** and **boundary conditions** for BSF projects, aligned where possible with international LCA practice, so that verified reductions can access **results-based climate finance** or be counted credibly toward NDCs. International LCAs comparing BSF treatment with composting or landfilling show orders-of-magnitude differences in direct CH_4/N_2O emissions, though results vary by substrate and system design. Incorporating this literature into local MRV protocols will help de-risk investments and, importantly, prevent **perverse incentives** (e.g., trucking low-quality, contaminated waste long distances in pursuit of climate payments).

6.8 Market development, procurement, and demand signalling

Early demand certainty accelerates private investment. Governments and development partners can issue **competitive procurement calls** for BSFL meal to partially substitute conventional protein concentrates in **public hatcheries**, **state-supported aquaculture outgrower schemes**, or **school feeding programmes** where appropriate nutrition standards are met. Transparent tenders with clear quality specs and delivery schedules function as market signals and **bankable offtakes**. Feed-mill associations can complement this by publishing **voluntary inclusion guidelines** for poultry and fish rations at various life stages, anchored in existing trial evidence and safety standards.

Public communication should be evidence-led and pragmatic. Farmers will adopt BSFL not because it is novel, but because it **works**: on growth performance, feed conversion, and cost stability. Extension materials should therefore focus on **how to formulate**, **how to store**, and **how to blend** BSFL with conventional inputs, clarifying what it can and cannot replace.

6.9 Social inclusion and decent work

The job numbers are meaningful not only in aggregate but in distribution. Because BSF units can be **modular** and located in secondary towns, they can offer **local formalisation pathways** for informal waste pickers and micro-haulers. Policy should encourage cooperatives and SMEs to enter, while setting **clear labour standards** on wages, safety equipment, and working hours. Where possible, public programmes should prioritise **women-led and youth-led enterprises** in procurement and concessional finance. These are not just equity goals; diverse operator bases improve resilience and innovation.

6.10 Regional coordination and trade facilitation

Feed and fertiliser markets in Eastern Africa are regional by nature. Harmonising product definitions, contaminant limits, and labelling rules for BSFL meal and frass will reduce transaction costs and unlock scale. Regional economic communities can create **mutual recognition** pathways for compliant products, building on Codex-aligned principles. Over time, a **regional code of practice** for insect producers drawing on EU's regulatory experience and FAO guidance can standardise good hygiene and biosecurity benchmarks, thereby easing cross-border investment and offtake contracts.

6.11 Implementation roadmap: sequencing actions over three horizons

Short-term actions (first **12 months**) should aim to **de-risk entry**. Regulators should **issue a positive list of species, basic substrate rules, and interim GHP/HACCP guidance for rearing an**d post-processing. Municipalities pilot **source-segregation** and **organics contracts** at two to three wholesale markets per city. Development partners capitalise a **guarantee window** for SME equipment finance (rearing racks, crates, dryers, mills). Standards bodies publish **draft BSFL meal and frass specifications** for comment. Universities and research institutes launch an **applied optimisation program** on local substrates and frass agronomy.

Medium-term actions (years **2–3**) should build **industrial reliability**. Waste-collection concessions expand to a network of **pre-processing spokes**; national labs accredit test methods; the first **traceability mark** is launched; and procurement programmes issue **multi-year offtake tenders** that require compliance with the new standards. Climate authorities publish **MRV protocols** for organics diversion and BSF treatment, enabling results-based finance for verified projects. Cross-border committees begin **harmonisation** of product definitions and contaminant limits.

Longer-term actions (years **4–6**) should consolidate **scale and trade**. Integrated facilities co-locate larvae, frass processing, and blending; regional mutual recognition agreements allow fertiliser and feed trade; and quality seals become standard in B2B transactions. Cities embed BSF diversion in their **solid-waste master plans**, while ministries of agriculture and fisheries integrate insect-protein substitution into sector strategies. At this stage, public finance can taper, with market discipline and private investment driving expansion.

6.12 Aligning with national priorities

These recommendations are not a special request for a niche technology, but a way to **hit multiple national targets with one policy bundle**. They reduce vulnerability to imported protein meals and foreign-exchange shocks; they improve urban sanitation and reduce landfill pressures; they create modular jobs where underemployment is high; and they contribute to climate commitments with measurable, verifiable outcomes. The modelling in this report demonstrates the macro-level returns—**GDP**, **jobs**, and **GHG reductions**—that governments often look for when prioritising interventions. The farmer surveys demonstrate the micro-level readiness to adopt. The decisive question is whether the policy environment will move quickly enough to convert potential into practice.

6.13 Recommendations on Prioritised policy actions

Within NESTLER, we believe that governments should act now to scale BSFL production and ensure that the benefits of this promising industry are realized, via the following prioritised steps:

1. **Publish an interim regulatory guidance** that clarifies permitted species, substrates, and hygiene expectations for BSFL meal and frass, drawing on international precedents while adapting to local conditions (EU 2017/893; EU 2021/1372; EU 2019/1009; FAO/Codex framing).
2. **Support Waste Recycling Initiatives**: Since BSFL farming aids in waste recycling and alleviating feed insecurity, governments should integrate BSF production into national waste management and feed strategies. In practical terms, they may restructure organics collection to deliver predictable, low-contamination streams to licensed BSF operators via source segregation and performance-based contracts. This can simultaneously address environmental challenges while promoting a circular economy.
3. **Incentivize Production**: Development partners and governments should provide incentives, such as tax breaks and subsidies, to entrepreneurs and cooperatives willing to invest in BSFL. This will help bridge the gap between current production and market demand. That includes the issue of product specifications and testing protocols for BSFL meal and frass, and accredit regional laboratories to keep compliance costs low.
4. **Strengthen Quality and Standards**: Establishing and enforcing standards for BSF larvae meal quality is essential to build farmer trust and ensure widespread adoption. Regional guidelines and certifications can promote consistent production practices and encourage cross-border trade
5. Deploy **targeted blended finance** for MSME equipment and integrated plants, complemented by time-bound tax measures and government-led offtake tenders that provide early demand certainty.
6. Install **MRV protocols** so that organics diversion and GHG benefits are measurable and financeable. Each action is straightforward on its own; taken together, they form a coherent enabling environment that lets the private sector do what it does best: invest, operate, and compete.
7. **Invest in Research and Infrastructure**: Public-private partnership should focus on advancing research to improve insect farming and its needed infrastructure, including developing low-cost technologies for smallholder farmers, and expanding capacity for large-scale production.

7 Conclusions

Black soldier fly (BSF) farming offers Eastern Africa a practical path to relieve feed bottlenecks while valorising urban and agro-industrial organics. Across Ethiopia, Kenya, and Rwanda, farmer surveys indicate near-universal intent to adopt BSF larvae as feed, with willingness-to-pay shaped by local price baselines, clear evidence that market pull already exists if supply, quality, and pricing are organized predictably.

Current production, however, falls well short of demand, reflecting early-stage industry structure, fragmented regulation, and limited post-processing capacity. This supply gap constrains poultry and aquaculture competitiveness despite abundant, technically suitable biowaste streams that could be converted into stable larvae meal and agronomically valuable frass.

Scaling potential is material. Country-level estimates of biowaste indicate substantial headroom for BSFL output, while economy-wide modelling links full utilization to meaningful gains in GDP, employment, and greenhouse-gas mitigation, benefits that arise not only from new insect-protein value added but also from displaced imports, improved waste management, and downstream multiplier effects.

Realizing this opportunity is chiefly an organization challenge. The report's policy package prioritizes regulatory clarity (permitted species, substrate rules, hygiene requirements), quality standards for BSFL meal and frass, source-segregated organics with predictable contracting, blended finance for MSMEs and integrated facilities, hub-and-spoke logistics with reliable drying/milling, and targeted extension, certification, and applied R&D. Together, these measures de-risk private investment, anchor early offtake, and professionalize operations.

NESTERL has also contributed in capacity building. Training programs in Kenya and Rwanda demonstrate how technical SOPs and entrepreneurship coaching seed locally owned enterprises and accelerate diffusion of good practice. Embedding measurement, reporting, and verification for organics diversion and emissions reductions will unlock results-based climate finance and strengthen public credibility.

In sum, BSF is no longer experimental; it is a systems solution awaiting scale. With coherent rules, clean inputs, trusted quality, and fit-for-purpose finance and logistics, Eastern Africa can convert organics into reliable protein and regenerative fertilizer—delivering tangible wins for producers, consumers, cities, and the climate.

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