Refugee Insect Production for Food and Feed

Black Soldier Fly Larvae

A Gamechanger for Refugee Farmers

Acknowledgements
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The report presents lessons learned from many years of work by Mothers Against Malnutrition and Hunger (MAMAH) to improve the incomes, health and nutrition of refugees and other vulnerable populations in Uganda. The RefIPro project was implemented by a consortium led in Uganda by MAMAH, with international co-ordination by Research & Action for Income Security (RAISE) and with research components led by Makerere University, University of Copenhagen and the International Centre of Insect Physiology and Ecology (ICIPE). The authors would like to thank all the staff and volunteers, including refugees and host community members, who contributed to this work.

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A MAMAH team member demonstrates the collection of eggs during BSFL production. Practical, hands-on technical support helped refugee and host community farmers develop the skills needed to establish and manage insect farming enterprises.

1. Introduction

According to the United Nations High Commissioner for Refugees (UNHCR), in September 2025, Eastern and Southern Africa hosted more than 25 million forcibly displaced people, including 6.3 million refugees and asylum seekers and 18.1 million internally displaced persons (IDPs).[1] This displacement is a result of protracted conflicts in Sudan, South Sudan, the Democratic Republic of the Congo (DRC) and Mozambique, as well as climate-induced disasters.

Uganda, the country with the largest refugee population in Africa, faces escalating tensions and protracted conflicts in neighbouring regions like the DRC and South Sudan. These conflicts have forced millions to flee, leading to a significant influx of refugees into Uganda. As an example, the Kyaka II refugee settlement in Western Uganda has seen its population grow from 50,000 to over 138,000 refugees in a few years, straining resources and social systems. In all the affected countries, the burden of caring for refugees and IDPs has overstretched the resources of the humanitarian system. In Uganda, the World Food Programme (WFP) has reduced rations by 40% due to funding shortfalls, and many refugees now face food insecurity.

The situation calls for urgent implementation of innovative approaches to empower refugees and reduce their dependence on external aid. In settlements like Kyaka II, where population pressures are growing, traditional livelihood options like large-scale agriculture are no longer viable. Innovative, land-efficient interventions are required to address refugees' challenges, while promoting sustainability and resilience.

Promoting edible insect production is one such way of contributing to better access to protein to improve the livelihoods of both refugees and host communities. The 'Refugee Insect Production for Food and Feed' (RefIPro) project, implemented in Kyaka II settlement between 2022 and 2026, supported the introduction of mealworm and black soldier fly larvae (BSFL) in the settlement. The project had two distinct objectives:

1. **Improved nutrition and health of refugee and host community children through the production of mealworm.** This objective focused on production of mealworm for food in both communities and schools. The project implemented an intervention study in two schools in and around the Kyaka II settlement and documented how adding mealworm to school meals affected the health and nutrition indicators of school children. This study is the first ever to examine the use of mealworm for enrichment of school meals.

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[1] www.unhcr.org/where-we-work/regions/eastern-and-southern-africa

2 **Improved incomes of refugees and host community members through production of black soldier fly larvae (BSFL).** The project trained a total of 965 refugees and host community members to produce BSFL to sell as feed, with the aim of providing a novel income-generating opportunity for refugees. Currently 500 are actively producing. The project also strengthened the capacity of local farmers associations and local authorities to provide continuous support to local BSFL producers.

Edible insect production has attracted growing interest in recent years from non-governmental organisations (NGOs), UN agencies, and governments due to its potential to enhance food security, livelihoods, and sustainability. Mealworm production offers a novel source of protein and other nutrients that can be produced locally, while BSFL farming provides a means of converting organic waste into high-protein feed for livestock and fish.

Despite this growing interest, there is limited publicly available information presented in an accessible format for practitioners. This gap is particularly pronounced in refugee settings and especially for mealworm production. To address this need, this report documents lessons learned from implementing insect production activities in refugee contexts.

The aim of this report is to share those lessons in a practical format that can serve as a starting point for organisations and practitioners interested in using BSFL production to strengthen refugee livelihoods and incomes. This report focuses on Objective 2: Black soldier fly larvae production, while a separate report presents lessons learned from Objective 1: Mealworm production.

BSFL breeding unit established in Rusese host community in Kyegegwa district. The project combined household-level production with community breeding systems to support access to rearing stock and enable wider adoption of BSFL farming among refugee and host community farmers.

2. Motivation

The promise of black soldier fly larvae

In refugee settlements where population pressures are growing, traditional livelihood options like large-scale agriculture are usually not viable. Innovative, land-efficient interventions are required to address refugee challenges while promoting sustainability and resilience. Promoting black soldier fly larvae (BSFL) farming is one promising approach. It enables the transformation of organic waste into high-protein feed for livestock and fish. BSFL production can contribute to improving livelihoods and incomes for refugees in several ways:

- As a technology that overcomes high feed costs for refugee farmers: In many countries, commercial feeds are expensive and often of uncertain quality. BSFL production functions particularly well as a way to produce local, affordable, and sustainable alternatives to commercial feed for small-scale poultry producers, pig farmers, and fish farmers.

- As a source of income for refugees: The sale of BSFL can provide a source of regular cash income for refugees who otherwise have very limited income sources. Many refugee BSFL farmers in the RefIPro project described how income from either the direct sale of BSFL or from increased incomes from livestock fed on BSFL, was what allowed them to pay school fees.

- As a waste management technology: Waste management is severely under-resourced in many low- and middle-income countries, and this is also the case in Kyegegwa District where the Kyaka II settlement is located. Given the lack of resources, district authorities often must resort to the use of landfills, or even to simply dumping waste. BSFL production offers an alternative biological treatment technology for organic waste. By increasing the value of organic waste, BSFL farming can offer incentives for the sorting and collecting of waste from households and markets.

- As a source of fertiliser for vegetable production: As with animal feed, commercial fertilisers are often expensive and of uncertain quality. The frass remaining after BSF larvae are harvested provides a valuable source of organic fertiliser for vegetable gardens and maize production in and around refugee settlements.

- As a way to achieve more environmentally sustainable food production: Global feed markets mainly rely on soy and fishmeal, however both of these protein sources are the causes of widespread environmental destruction. Large-scale soy production in Brazil for export is driving deforestation[2] and the use of fishmeal in aquaculture feed contributes to overfishing of the oceans.[3] BSFL farming provides a locally produced and environmentally friendly alternative protein source for animal feed, suitable for poultry, fish, and pigs.

In conclusion, BSFL farming can be viewed as a very promising technology for boosting a circular food production economy in and around refugee settlements.

[2] https://trase.earth/insights/brazilian-soy-exports-and-deforestation

[3] https://changingmarkets.org/campaigns/fishing-the-feed/

3. The context of the RefIPro project

The Kyaka II refugee settlement in Western Uganda

The Kyaka II Refugee Settlement, located in Kyegegwa District in Western Uganda, is one of the most rapidly growing refugee settlements in the country. The settlement hosts predominantly refugees from the DRC, alongside smaller populations from South Sudan and other neighbouring countries affected by conflict and instability. Continued insecurity and protracted conflicts in the region have led to a sustained influx of new arrivals into the settlement over recent years, placing significant pressure on humanitarian systems, social services, natural resources, and livelihood opportunities.

The humanitarian context within Kyaka II is characterised by high levels of food insecurity, poverty, unemployment, and vulnerability among refugee households. Due to global funding shortfalls, the WFP has significantly reduced food rations for refugees, leaving many households unable to meet their minimum food and nutritional requirements.

These cuts have contributed to worsening dietary diversity, inadequate protein intake, and increased nutritional vulnerability, particularly among children and women. Chronic malnutrition remains a major public health concern, with stunting levels estimated at approximately 42% among children in the settlement (UDHS 2022), reflecting long-term nutritional deprivation and poor feeding conditions.

Upon arrival in the settlement, refugee households are allocated small plots of land intended for shelter construction and limited household food production. Historically, these plots measured approximately 30 by 30 metres. However, the rapid increase in refugee numbers is leading to growing constraints on the amount of available land, in turn leading to further subdivision of plots to accommodate new arrivals. As a result, many households now have insufficient land to produce enough food for their families. Traditional agriculture, which depends on larger land areas and favourable climatic conditions, has therefore become increasingly unsustainable and inadequate as a livelihood strategy within the settlement.

At the same time, opportunities for formal employment and income generation remain extremely limited. Many refugees have low levels of formal education and limited vocational skills, while language barriers further constrain economic integration. A significant proportion of refugees in Kyaka II are French-speaking Congolese living within an English-speaking national context, which limits access to employment opportunities. Consequently, many households remain heavily dependent on humanitarian aid, even with the declining assistance levels.

The settlement therefore faces a complex combination of nutritional, economic,

Kyaka II settlement in Western Uganda is home to more than 138,000 people. Refugees in Uganda are provided with small plots of land and are allowed to work. But plots are too small to feed a family and income opportunities very limited. There is an urgent need for new sources of income and livelihoods.

and livelihood challenges that require innovative and context-appropriate solutions. There is a growing need for interventions capable of producing nutritious food and generating income within highly constrained environments characterised by limited land, limited capital, and limited technical capacity. Such interventions must also be simple to adopt, affordable, scalable, and suitable for vulnerable populations with minimal formal training.

It is within this context that the RefIPro project introduced mealworm and BSFL farming as innovative approaches for strengthening nutrition and livelihoods among refugees and host communities. Insect farming presents a highly suitable solution for densely populated humanitarian settings because it requires very limited space, low water use, modest infrastructure, and relatively simple management systems. In addition, insect farming provides opportunities for improvements in both household nutrition and income generation, while at the same time contributing to more sustainable and resilient local food systems.

4. Introducing BSFL production in a refugee settlement

4.1. Overview

Production of black soldier fly (Hermetia illucens) larvae represents an innovative and rapidly emerging approach for converting organic waste into high-quality protein for animal feed and organic fertiliser. The larvae are voracious feeders capable of converting large quantities of organic waste into nutrient-rich biomass within approximately 10–14 days.

Under the ReflPro project, BSFL production was introduced in the Kyaka II refugee settlement as a livelihood-focused intervention aimed at creating low-space, low-cost, and scalable income-generating opportunities for both refugee and host community households.

The black soldier fly is a harmless insect species whose larvae are highly efficient at consuming and converting organic waste into nutrient-rich biomass. The larvae can feed on a wide range of biodegradable materials, including market waste, household food leftovers, fruit and vegetable residues, agro-processing by-products, and animal manure.

As they feed, the larvae rapidly grow and accumulate high levels of protein and fat, making them an excellent ingredient for poultry, pig, and fish feed. In addition, the residue remaining after larval feeding, commonly known as frass, is a valuable organic fertiliser that can be used to improve soil fertility and crop production.

One of the major advantages of BSFL production in refugee settings is its compatibility with highly constrained environments. The system requires relatively little land, modest infrastructure, and simple management practices compared to many traditional agricultural enterprises. BSFL farming also creates opportunities to transform locally available organic waste streams into valuable economic products, contributing to circular economy approaches and improved environmental management within densely populated settlements.

4.2. Basics of BSFL Production

***The BSFL life cycle*:** The black soldier fly undergoes a complete metamorphosis consisting of four distinct life stages: egg, larva, pupa, and adult. Each stage plays a critical role in the insect's development, reproduction, and ability to convert organic waste into valuable biomass. Understanding the life cycle is fundamental for successful black soldier fly rearing, as environmental conditions, feeding practices, and management requirements vary considerably between stages. Figure 1 illustrates the complete life cycle of the black soldier fly and highlights the progression from egg deposition through to adult emergence.

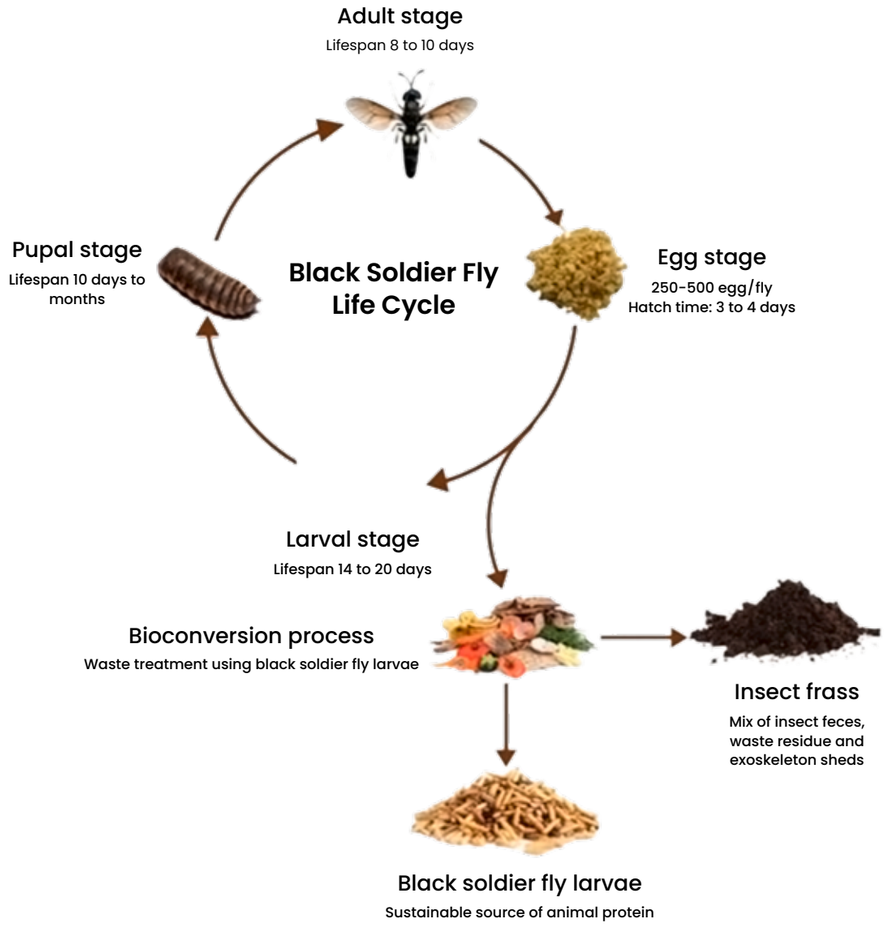

Figure 1: *The life cycle of the black soldier fly.*

***Breeding (adult colony)*:** The BSFL production cycle typically begins with adult flies laying eggs in crevices near an attractant. Adult flies are maintained in netted breeding cages, commonly referred to as "love cages," under favourable environmental conditions, including adequate light exposure, temperatures of approximately 27–32°C, and humidity levels of 50–60%. Adult flies do not feed, although they may access water, and mating generally occurs within three days after emergence.

***Egg harvesting*:** Female flies lay eggs in small crevices close to a decomposing substrate that acts as an attractant. The eggs are usually collected daily or every two days to maintain consistent production cycles.

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***Hatching and nursery stage*:** The eggs hatch within approximately three to four days. Once hatched, the neonates (young larvae) are transferred to nursery containers and fed on soft, nutrient-rich starter substrates such as chicken mash or even maize bran to support early growth and survival.

***Rearing and feeding*:** After the nursery stage, the larvae are transferred to rearing containers containing organic waste substrates. During this stage, the larvae aggressively consume organic material over a period of approximately two weeks, rapidly converting waste into high-value protein biomass. Depending on the type of substrate, some waste materials may require pre-processing such as chopping, crushing, or fermentation before feeding to improve digestibility and larval performance.

***Harvesting*:** At approximately 10–14 days, the cream-coloured larvae are harvested by separating them from the frass using mesh sieves or other separation methods. The harvested larvae may be processed into animal feed products or sold directly to livestock farmers. A proportion of the larvae is retained as brood stock and allowed to pupate in order to sustain the breeding cycle.

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In Kyaka II refugee settlement, Ugandan organization Mothers Against Malnutrition and Hunger (MAMAH) has established market waste collection points with displays showing how BSF production enables the use of market waste to produce protein and fertilizer.

4.3. BSFL production models

BSFL production systems range from highly simplified household operations to sophisticated industrial facilities. Four major production models are briefly described below.

***Small-scale household model*:** This model is commonly practiced by smallholder farmers and households primarily to produce on-farm feed for poultry or fish, thereby reducing dependence on expensive commercial feeds. The systems are generally characterised by low investment and simple tools, utilising locally available materials such as plastic containers and shaded outdoor structures. Feed substrates commonly include household waste, nearby market waste, and livestock manure.

***Commercial / industrial model*:** Commercial BSFL production systems are large-scale operations focused on producing substantial volumes of larvae, dried larvae meal, or processed protein ingredients for industrial feed markets. These systems are typically characterised by mechanised feeding systems, climate-controlled environments, automated waste handling, and specialised processing infrastructure. Feed substrates mainly include industrial food waste, agro-industrial by-products, and agricultural residues. In addition to larvae protein, these systems also produce significant quantities of frass for commercial organic fertiliser markets.

***Integrated circular bioeconomy model*:** This model focuses on integrating BSFL production within broader agricultural and food processing systems to enhance sustainability and resource efficiency. BSFL facilities are often located near food processing plants, breweries, markets, or large farms, where waste streams can be directly converted into insect protein and organic fertiliser. This model promotes circular economy principles by turning waste into productive agricultural inputs while reducing environmental pollution.

***Specialised breeding model (hatchery)*:** This model focuses specifically on the production of eggs and young larvae rather than mature larvae for feed purposes. Hatcheries primarily supply eggs or young larvae (commonly referred to as five-day-old larvae or hatchlings) to other BSFL producers requiring consistent starter stock. This system places particular emphasis on maximising mating efficiency, egg production, and brood stock management. Special attention is given to environmental control and brood stock nutrition in order to improve fecundity and ensure reliable egg production.

A farmer tends BSFL in a space-efficient nursery production facility in Bukere, Kyaka II refugee settlement. Vertical stacking of rearing containers enables farmers to increase production within limited space, an important advantage in densely populated refugee and smallholder settings.

5. Setting up production

As mentioned, one of the major strengths of BSFL farming in refugee settings is that it can be established with relatively low capital investment and limited land requirements. However, successful production still requires appropriate training, regular follow-up support, and access to basic production equipment. Experiences from the ReflPro project demonstrated that providing startup materials alone was insufficient. Continuous mentorship and technical guidance were essential for farmers to achieve stable production and avoid early dropout. The project therefore combined practical hands-on training with ongoing field follow-up by extension staff and lead farmers.

5.1. Farmer training

Establishing successful BSFL production among smallholder and refugee farmers requires a combination of practical training, continuous technical support, provision of appropriate rearing containers, and upfront investment in egg-production systems.

Within the context of the ReflPro project, egg production and nursery management were centrally managed, while farmers received five-day-old larvae (5-DOL) for onward rearing. As such, farmer training primarily focused on larval growth stages, feeding requirements, harvesting techniques, and hygiene management.

The training approach was highly practical and demonstration-based, with theoretical content deliberately minimised and mainly used to provide foundational understanding before practical sessions. For example, the training only briefly covered the biology and life cycle of the BSFL. This applied approach was particularly important because many participating farmers had low literacy levels, and communication frequently relied on interpreters due to language barriers within the refugee settlement. Practical demonstrations therefore became essential in ensuring accurate understanding and skills transfer, even where interpretation challenges existed.

By excluding the more technically demanding aspects of egg production and nursery management, farmers were able to quickly grasp the simpler but practically important component of larvae rearing. Consequently, the initial training for each cohort was conducted within two days. However, the short training duration also made routine follow-up support and supervision indispensable.

Lead farmers receive training in egg production and the management of the community breeding centres. Practical demonstrations, reinforced by regular mentorship and follow-up, enabled them to acquire the skills needed for successful breeding and provision of onward peer support. Photo: MAMAH

Continuous technical support proved especially critical during the first production cycles. Many farmers initially struggled with maintaining appropriate substrate moisture levels, managing feed quality, and optimising larval stocking densities. Mentorship and regular support supervision therefore played a major role in improving farmer confidence, reducing early production losses, and sustaining participation. Experience from the project demonstrated that when farmers encounter the inevitable challenges associated with implementing a new technology without immediate support, dropout rates increase significantly. Routine field follow-up by the project team was therefore a major success factor.

The project experience also demonstrated the importance of identifying and supporting lead “champion farmers” who could continue mentoring others within the settlement after external project support declined. These experienced farmers became important local resource persons for training, troubleshooting, and mobilising new producers.

Another critical success factor was the provision of starter rearing kits immediately after training, enabling farmers to directly apply their newly acquired skills.

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> One of the most critical investments is the establishment of reliable breeding systems capable of producing a consistent egg supply.

Within Kyaka II refugee settlement, farmer associations, the insect farmers' cooperative, and community breeding centres also became important support structures for peer learning and continued access to rearing stock.

5.2. Investments required for BSFL production

One of the key advantages of BSFL farming is its flexibility: systems can be established at very low cost for household-level production, but they can also be scaled into more commercial operations requiring greater investment.

The level of investment required for BSFL production thus depends largely on the scale and production model adopted. Small-scale household systems can begin using simple, locally improvised materials such as plastic basins, buckets, tarpaulins, untreated mosquito nets, and locally fabricated cages.

Community-level and semi-commercial systems, however, require more structured infrastructure, including breeding cages, egg-collection systems, nursery facilities, brood-stock management units, harvesting and drying equipment, as well as waste collection, preprocessing, and storage areas.

One of the most critical investments is the establishment of reliable breeding systems capable of producing a consistent egg supply. Without dependable access to eggs or young larvae, farmer production quickly becomes unstable, undermining both productivity and commercial viability. Community breeding centres, such as those established in the Kyaka II refugee settlement, therefore play a critical role as centralised hubs for maintaining breeding colonies and distributing eggs or young larvae to farmers.

5.3. Optimising production kits

Optimising BSFL production kits is essential for improving productivity, reducing labour requirements, and ensuring the technology remains adaptable to refugee and smallholder contexts. Production kits must remain low-cost, durable, easy to maintain, and wherever possible, constructed using locally available materials.

In the Kyaka II refugee settlement, both farmers and the project team continuously modified initial production designs based on practical field experience. Early production systems relied heavily on large cylindrical drums, which later proved inefficient in terms of space utilisation and cost. These were gradually replaced with smaller jerrycans and stackable container systems that allowed higher stocking densities within smaller production spaces.

Over time, production kits continued evolving in response to farmer feedback, operational realities, and locally identified challenges. Practical innovation therefore became an ongoing and highly participatory process shaped by experimentation and farmer-driven adaptation.

5.4. Safeguarding against thieves, pests, and predators

Protecting BSFL production units from thieves, pests, and predators is one of the major operational challenges in insect farming. Rats, red ants, lizards, and birds can significantly reduce productivity by feeding on larvae or disrupting breeding systems. Ants are particularly destructive and can eliminate entire colonies within a very short period.

Several low-cost protective measures were introduced during the project. Water trenches were constructed around breeding units to limit ant invasion, while vertical production systems placed on stands utilised oil barriers to prevent ants from climbing into containers. Fine mesh nets were used to protect nursery units from birds and unwanted insects, while maintaining clean and uncluttered production spaces helped reduce lizard infestations.

The construction of enclosed production shelters with lockable doors also helped reduce theft of larvae and equipment. In refugee settlement contexts, where production units are often located within communal areas, theft can occasionally occur. However, strong farmer group organisation, cooperative management structures, and community ownership mechanisms significantly strengthened accountability and collective protection of production facilities.

In addition, breeding areas were fenced using chain-link fencing and equipped with solar lighting to improve night-time visibility and reduce opportunities for theft and vandalism.

5.5. Controlling the production environment

In small-scale production systems such as those established in the Kyaka II refugee settlement, farmers largely rely on naturally favourable tropical conditions, reducing the need for sophisticated environmental control systems. The warm and humid climate generally provides suitable conditions for BSFL production.

Nevertheless, several environmental factors remain critical for maximising larval growth rates and waste conversion efficiency. Since BSF larvae are photophobic, shaded production environments are essential. Adequate ventilation and air circulation must also be incorporated into housing designs to prevent overheating and maintain suitable humidity levels.

Particular attention must be given to substrate moisture management, as the feeding substrate simultaneously serves as the larvae's living environment. Proper balancing of moisture, airflow, shade, and hygiene therefore remains central to successful BSFL production.

6. Organising production

Within the ReflPro project, two main BSFL production systems emerged: the decentralised household-level production, and the cooperative/community-based production system. Farmers chose to engage either individually at the household level or collectively through farmer associations and cooperative structures, depending on available resources, production goals, market orientation, and access to space.

6.1. Household BSFL production

Most farmers opted for small-scale household BSFL production managed directly within refugee and host community households. Farmers utilised simple, locally available materials such as basins, buckets, and improvised rearing containers to establish production units within small household compounds. Organic waste collected from nearby households and markets was used as larval feed.

This form of production proved particularly attractive because of its low start-up costs, flexibility, and adaptability to the refugee settlement context. Farmers were able to begin production with minimal capital investment and gradually expand operations as they gained experience and confidence. Household-level production was primarily oriented toward producing larvae as a cost-reduction strategy for feeding poultry, pigs, and fish, thereby reducing dependence on expensive commercial feeds. In addition, farmers utilised frass, the organic residue from larval production, to support backyard vegetable gardening and to further diversify household diets.

However, household-level production also faced several operational challenges. Reliable access to sufficient quantities of organic waste was often difficult within the settlement, where widespread food insecurity meant relatively little household waste was generated. As a result, farmers increasingly depended on organised waste collection systems coordinated through farmer associations and the cooperative.

6.2 Collective production models'

As the project evolved, more organised and collective BSFL production systems gradually emerged. Farmer groups established shared rearing facilities capable of producing larger quantities of larvae within centralised production spaces. In some cases, these groups also operated joint poultry or fish farming enterprises, utilising the BSFL produced to feed their livestock, thereby significantly reducing feed costs and increasing profit margins. In other cases, larvae were sold commercially, with profits shared among group members.

Beyond production itself, cooperative-managed systems contributed to improved production quality, stronger peer learning, collective problem-solving, and emerging opportunities for value addition. Farmers were able to exchange experiences and collectively address challenges affecting productivity.

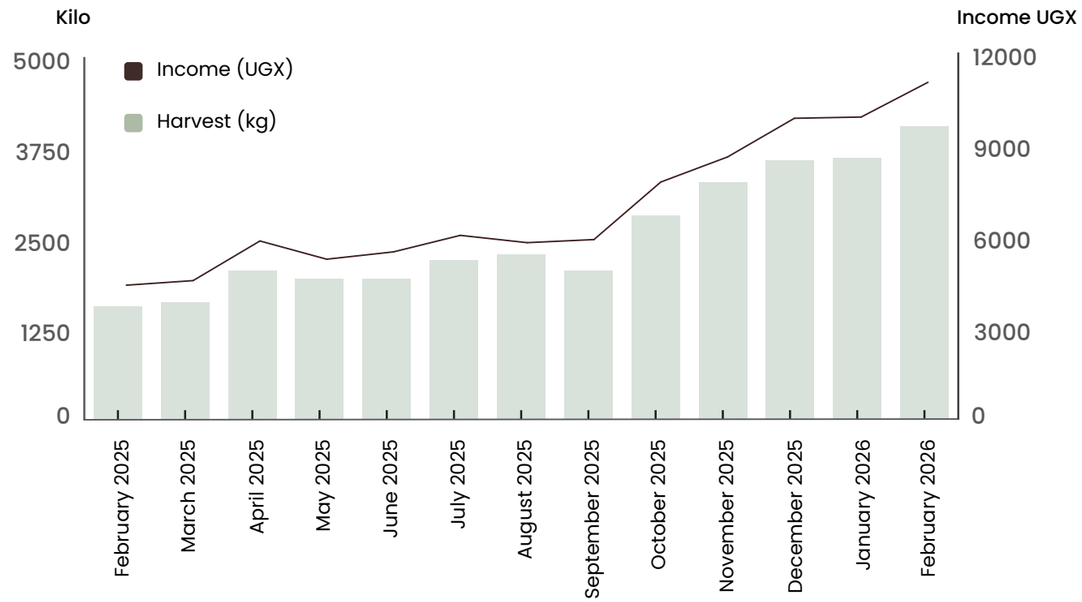

Figure 2: *BSFL harvested by farmers in the ReflPro project 2025-2026 and market value of production (in Ugandan shillings) Source: ReflPro project monitoring data.*

The cooperative model strengthened coordination around waste collection, input supply, technical support, and market organisation. By working collectively, farmers were better able to negotiate access to organic waste from markets, organise transportation logistics, and engage potential buyers for larvae and related products. This collective approach proved especially important in the refugee settlement context, where individual farmers often lacked adequate transport capacity, storage facilities and bargaining power.

Over time, the cooperative structures increasingly became important sustainability mechanisms capable of supporting long-term expansion, improving farmer organisation, strengthening market access, and enhancing the commercial viability of BSFL production systems within the settlement and surrounding host communities.

In the ReflPro project, 25 farmers associations produced on average 150 kilos of fresh larvae per group per month. At a market value of UGX 3,000 per kilo, this represented an average monthly value of UGX 450,000 per group (about USD 120). As each group had on average 20 members, the average value of the production per person per month was UGX 22,500 (about USD 6). Figure 1 shows the development in the total harvested kilos of larvae (fresh weight) and the market value of the production (in Ugandan shillings) from the approximately 500 active farmers in the two districts of Kyegegwa (including both refugees and host community members) and Mityana.

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6.3. Managing egg production

Management of BSFL egg production emerged as one of the most critical components of sustaining larval production systems under the RefIPro project. As already noted, egg production was centralised within community breeding centres established in farmer communities to ensure reliable farmer access to quality rearing stock. One such breeding centre was established in the Bukere Zone within the Kyaka II refugee settlement, and is managed by trained lead farmers drawn directly from the refugee and host communities.

Lead farmers received specialised training in BSFL egg production and nursery management at Bobo Eco Farm in Mityana. Their responsibilities include managing adult breeding colonies, overseeing egg production and nursery operations, and distributing five-day-old larvae to farmers for onward rearing. Centralising the more technically demanding stages of production allowed the majority of farmers to focus on the relatively simpler larval rearing stage, thereby improving adoption rates and reducing early technical failures.

To further strengthen organisation and sustainability, farmers were supported to establish an Insect Farmers' Cooperative serving as an umbrella structure bringing together the different farmer groups engaged in insect production.

Through this federated structure, farmers gained a stronger collective voice, improved coordination of market opportunities, and established mechanisms for jointly managing common infrastructure such as insect breeding facilities and waste collection systems.

The cooperative structure proved particularly important in organising access to organic waste streams for larval feed and coordinating technical support among members. Experience from the project demonstrated that investment in strengthening such community institutions is critical for promoting community ownership, operational sustainability, and long-term scaling of insect farming systems.

Photo: MAMAH

Breeding centres owned by farmer cooperatives (above) supply five-day old larvae to farmers for rearing. Within a few weeks the larvae are ready for harvesting (below).

Photo: MAMAH

Alongside the centralised breeding-centre model, individual farmers can also be empowered to manage the entire BSFL production cycle independently at household level, including egg production, nursery management, and larval rearing using simple netted systems. This decentralised approach reduces farmer dependence on centralised breeding centres and supports more organic expansion of production within the community. As neighbouring farmers learn from each other, new entrants can begin production relatively easily by acquiring simple netted cages and locally improvised production materials.

Beyond the sale or utilisation of larvae for poultry, pig, and fish feed, an emerging market for BSF eggs is also beginning to develop. Some farmers and commercial actors are either unwilling or unable to manage the complete production cycle and therefore prefer purchasing eggs or young larvae for onward rearing. This growing demand for eggs and starter colonies presents an important commercial opportunity worthy of further exploration, particularly for farmer cooperatives and specialised breeding centres that can focus on large-scale, reliable egg production and distribution.

6.4. Processing

Within the context of the RefIPro project, the majority of farmers produced BSFL primarily for direct feeding of poultry and fish or for sale to neighbouring farmers who purchased the larvae in fresh form. Processing at both household and group levels therefore remained relatively basic and limited to primary forms of preservation.

The most common processing practice among farmers was sun-drying the larvae to extend shelf life and improve storage stability. Drying also created opportunities for farmers to access buyers beyond their immediate villages, since dried larvae are easier to transport and less perishable than fresh larvae. This simple form of processing therefore represented an important first step toward commercialisation.

An important example of value addition also emerged among one farmer group in Kakoni village, within the host community. This group progressed beyond simple drying and began processing BSFL into a protein concentrate to sell to other livestock farmers as a feed ingredient. This demonstrates the growing potential for farmer-led innovation and movement toward higher-value insect-based feed products.

As farmers continue expanding production and transitioning from subsistence-oriented rearing towards more commercial operations, it is becoming increasingly clear that stronger cooperative approaches to production, bulking, processing, branding, and marketing will be necessary. Individual farmers often lack the volumes, equipment, and technical capacity required for higher-level processing and market development. Cooperative structures provide important opportunities for collective investment in processing infrastructure, quality control, packaging, storage, and market access. It is therefore pertinent as well to focus more investment into developing the farmer cooperative structure.

Kanane bikanyari a lead BSFL farmer in Kyaka II refugee settlement has designed an integrated model that produces BSFL, raises poultry. Has a fish pond underneath and finally uses the BSFL fertilizer to produce vegetables.

7. Barriers to production

> **Successful breeding depends on maintaining healthy adult fly colonies that begin with a properly fed brood stock.**

Based on the experiences of the ReflPro project, several key barriers continue to limit the successful expansion and sustainability of BSFL production within refugee and host community settings. While the technology has demonstrated strong potential as a low-space, climate-smart livelihood opportunity, it is also clear that production systems remain highly dependent on a few critical enabling factors. The three most significant barriers identified were:

1. Insufficient production of BSF eggs;
2. Inadequate access to feedstock; and
3. Limited access to credit to support organic expansion beyond project assistance.

The project has sought to overcome each of these barriers.

7.1. Ensuring production of sufficient BSF eggs

One of the most significant technical bottlenecks in BSFL production is maintaining a stable and sufficient supply of eggs or young larvae for farmers. Egg production requires more specialised infrastructure, technical knowledge, and management skills than larval rearing itself.

Successful breeding depends on maintaining healthy adult fly colonies that begin with a properly fed brood stock, and proceed with carefully controlled conditions, including adequate light exposure, proper humidity, temperature regulation, and well-managed attractant systems for egg laying.

Within the refugee settlement context, many farmers lacked the confidence, infrastructure, and financial capacity to independently manage full breeding systems. As a result, the ReflPro project initially centralised egg production through community breeding centres managed by trained lead farmers and the insect farmers cooperative. While this significantly improved access to rearing stock, demand for eggs and five-day-old larvae often exceeded available supply, particularly as more farmers became interested in joining production.

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A farmer tends BSFL rearing containers at a satellite BSFL breeding centre in Rusese village, Nkanja subcounty Kyegegwa district. Reliable access to eggs and young larvae, combined with appropriate management of production units, is essential for maintaining continuous production and enabling farmers to scale their enterprises.

Interruptions in egg supply directly affected farmer confidence and continuity of production. Farmers who failed to access starter colonies in time often abandoned or reduced production activities. The experience demonstrated that sustainable scaling of BSFL farming requires substantial investment in decentralised but reliable breeding and hatchery systems capable of producing sufficient eggs throughout the year or individualised breeding systems managed by individual farmers. Going forward, the project is seeking to expand egg production among the more experienced lead farmers and farmers associations.

7.2. Access to sufficient quantities of feedstock

A second major barrier was reliable access to adequate quantities of organic waste for feeding larvae. BSFL production depends heavily on consistent availability of biodegradable organic materials such as market waste, food leftovers, fruit residues, and agro-processing by-products. However, within refugee settlement environments characterised by widespread food insecurity, very little household food waste is generated.

At the household level, many farmers struggled to secure enough feedstock to sustain larger-scale larval production. Competition for organic waste also increased as the number of producers expanded. This challenge gradually pushed farmers toward more organised waste collection systems linked to markets, restaurants, and agro-processing factories.

The project demonstrated that organised access to waste streams is not simply a logistical issue, but a central determinant of production viability. Farmers associations and the cooperative became critical structures for negotiating access to market waste, organising transportation, and coordinating waste distribution among producers. Nevertheless, transportation costs and waste sorting requirements remained persistent operational constraints. The project has initiated conversations with the district local governments to support insect farmers' access to waste for example by passing by-laws requiring waste sorting at source. The next section provides more details on efforts to improve access to feedstock.

Photo: Rasmus Schjødt

The main market in Kyaka II refugee settlement. Organic waste from markets can provide a valuable source of feeds for BSFL production, but sorting and collecting it takes time and usually comes at a cost.

7.3. Limited access to credit for organic expansion

The third major barrier was the farmers' limited access to affordable credit and investment capital to support gradual expansion of production systems. Although BSFL farming can begin with relatively low investment, scaling production beyond subsistence level requires additional infrastructure, improved rearing systems, protective shelters, drying facilities, and waste collection and transportation arrangements.

Most refugee and host community farmers lacked access to formal financial services and affordable credit. Refugee farmers in particular faced additional challenges related to collateral requirements, unstable incomes, and limited financial inclusion. Consequently, many farmers remained trapped at very small production scales despite strong local market demand and growing technical experience.

The project observed that where farmer groups established savings and credit arrangements through the cooperative structure, members were better able to gradually improve production facilities and expand operations. However, access to larger-scale financing opportunities remains limited. Sustainable expansion of BSFL production within refugee settings will therefore require innovative financing approaches, including cooperative savings and micro-credit schemes, and stronger linkages with inclusive financial institutions capable of supporting emerging insect-based enterprises. Supporting such avenues is therefore a priority for future work.

8 . Access to feedstock

As mentioned above, access to sufficient sources of feedstock is one of the most important prerequisites for successful BSFL production, and is likely to be one of the main barriers in a refugee context. This section describes the main types of feedstock used in the RefIPro project, how they affect performance of BSFL, as well as initiatives taken to improve access to feedstock for refugees.

8.1. Sources of feed for BSFL

In the RefIPro project, the main sources of feedstock were market waste, cattle dung, and maize bran. Experiments were carried out to assess the effects of different combinations of feedstock on larvae growth. The shortest larval developmental time of 15 days was achieved using substrates made of 50% cattle dung and 50% maize bran, as well as with 25% cattle dung and 75% maize bran (Table 1). The combination of cattle dung and maize bran also showed the highest larval yield.

In addition, combining cattle dung and market waste demonstrated much better performance than cattle dung alone or market waste alone. Substrates consisting of sole cattle dung produced larvae with the long developmental time of 30 days and very low yield of 98 gram. Market waste alone performed better, but the mix of market waste and cattle dung was far superior, as shown in Figure 3.

BSF larvae that were fed on cattle dung manure and maize bran combinations had the highest dry matter, crude fat, ash, energy, and carbohydrates contents. The larval BSF fed solely on market waste accumulated higher phosphorus, sodium, and iron.

Including maize bran in the feed therefore has positive effects, but farmers should consider whether the slightly shorter developmental times and higher yield is worth the additional cost of maize bran compared with market waste. It is possible that lower percentages of maize bran in feeds that combine cattle dung and market waste as the main components is the best approach when considering costs, availability, and performance.

8.2. Improving access to market waste

As demonstrated through the RefIPro project, market waste represents one of the most valuable and reliable feed resources for BSFL production. However, within refugee settlement contexts, access to sufficient quantities of organic waste remains a major challenge due to food scarcity, limited household waste generation, and the costs associated with waste collection, sorting, and transportation.

To address this, the project supported farmer groups and the insect farmers co-

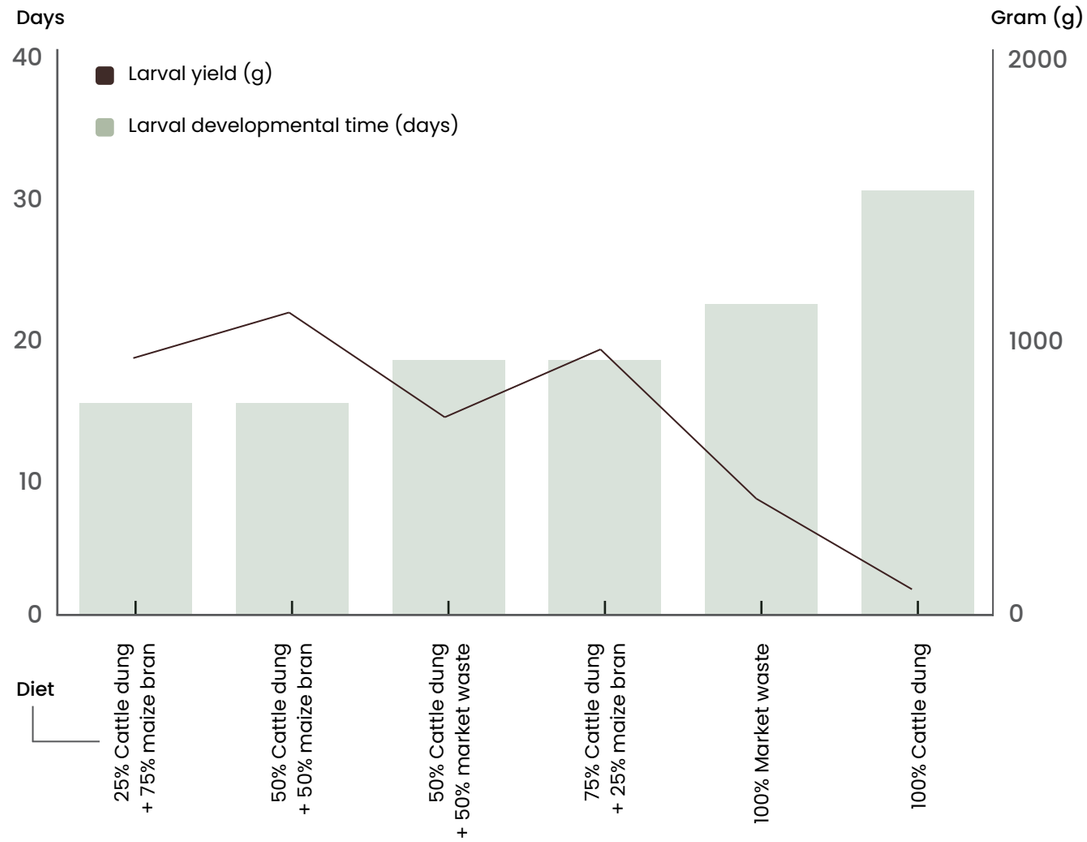

Figure 3: *Effects of different combinations of feed sources on BSF larvae developmental time and yield.*

operative to establish organised waste collection systems from fresh food markets within the settlement and surrounding host communities. The project also facilitated partnerships with market vendors, waste collectors, and local leaders to improve waste segregation, collection points, transportation, and long-term access to organic feedstock for BSFL farmers.

In most places, there is likely to be some kind of organisation of waste sorting and

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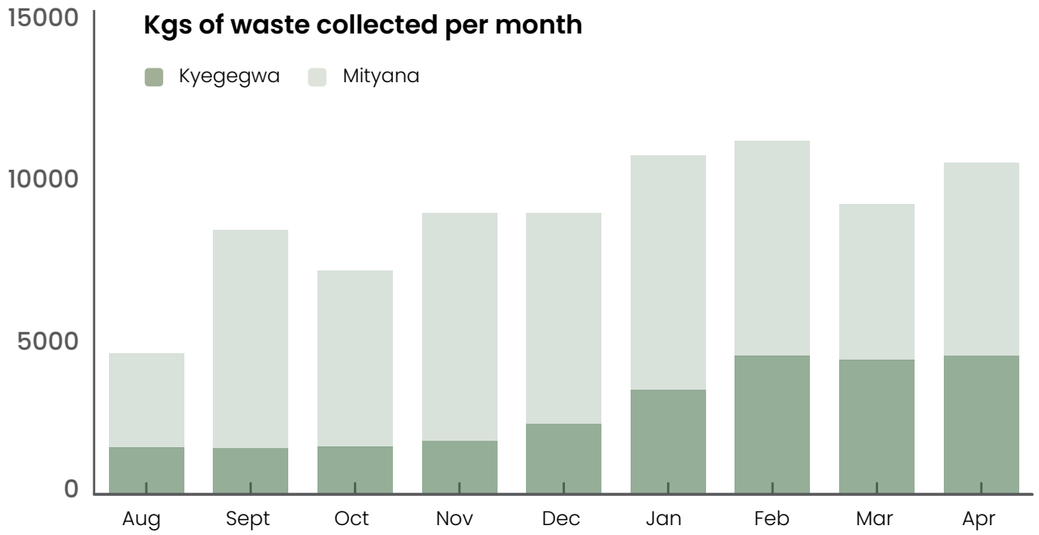

Figure 4: *Amount of waste collected in 2025-2026 in the InsectScale Project aimed at improving access to waste for BSFL farmers in Kyegegwa and Mityana Districts. Source: MAMAH monitoring data from InsectScale project.*

collection that needs to be taken into account when attempting to improve access to waste. For example, in some contexts, waste management is contracted out to companies who may or may not be interested in cooperating. Most markets are likely to have market associations or other forms of organisations managing them, which may serve as entry points for making agreements with vendors about sorting of organic waste.

One potential challenge is how to cover the costs people incur when sorting and collecting waste. Even if market waste itself is nominally free, there is significant cost involved in sorting and collecting the waste; for example, there are often high transport costs involved in moving waste from the source to the producers. These costs can be prohibitive relative to the limited income that can be generated from BSFL production. It is not a given that it is possible to find a common position between what BSFL farmers can pay and what waste sorters and collectors demand.

As mentioned, BSFL farming can be seen as a waste management technology, and this framing may be useful when approaching local authorities who are responsible for waste management yet usually have very limited resources for doing so. Here, BSFL producers can position themselves as offering the valuable service of disposing of organic waste. Local authorities can help create incentives for vendors and other waste producers to sort waste, for example by introducing higher fees for the collection of unsorted waste.

Figure 4 shows data on the amount of collected waste (kilos per month) before and after efforts to establish an improved system for collection and sorting of organic waste from markets in Kyegegwa and Mityana Districts. While the waste collection systems established by the project have been successful in increasing access to waste for BSFL farmers, it remains to be seen whether farmers will be able to continue covering the costs of maintaining the waste collection system, including in particular the cost of transporting waste.

One option for opening up more potential sources of feed is to ferment the plant material that is locally abundant and does not currently have other uses. In the area around the Kyaka II settlement, banana trees are abundant, and the use of fermentation to prepare banana pseudo stems for BSFL could present a major source of feed. Another potential food source, already being harnessed by the company Proteen in Western Uganda, is organic waste from coffee production.

BSFL production turns collected organic waste into valuable animal feed. Improved access to organised waste streams from markets in Kyegegwa and Mityana helped farmers secure the feedstock needed to sustain larvae production.

Refugee and host community farmers use the larvae as a protein-rich feed ingredient for poultry, reducing dependence on costly commercial feeds and strengthening the profitability and resilience of their poultry enterprises.

9. Uses of BSFL produce

Within the ReflPro project, BSFL production has evolved as both a livelihood activity and an important on-farm feed solution for refugee and host community households.

Most farmers use a dual-purpose approach, in which part of the larvae produced is sold to generate immediate household income, while another portion is retained for feeding their own poultry, pigs, or fish.

This balance between household utilisation and commercialisation has been particularly important within the refugee settlement context, where families face both limited income opportunities and immediate food needs at home due to a decline in humanitarian aid.

9.1. Protein feed ingredient

The primary use of BSFL among participating households has been as a protein-rich feed ingredient for poultry and aquaculture. The use of BSFL as a protein supplement in poultry production demonstrated significant benefits among refugee and host community farmers participating in the ReflPro project. Farmers reported improved growth performance, increased body weight gain, enhanced egg production, and better general health of chickens fed on fresh or dried BSFL.

BSFL farming helped reduce dependence on expensive commercial feeds, which are often unaffordable for smallholder and refugee households. By partially replacing commercial protein sources such as fish meal and soybean meal, farmers were able to lower feed costs while maintaining productivity.

In addition, the availability of locally produced larvae improved feed accessibility within the settlement and surrounding communities. The integration of BSFL into poultry systems therefore contributed not only to improved household income and profitability, but also to greater resilience of small-scale poultry enterprises in resource-constrained refugee settings.

BSFL production also contributed positively to small-scale fish farming activities by farmers within and around the Kyaka II refugee settlement. Farmers utilised BSFL as a high-protein feed ingredient for fish, particularly catfish and tilapia. The larvae improved feed availability and reduced reliance on costly commercial fish feeds, which represent one of the biggest operational costs in aquaculture. Farmers reported improved fish growth rates and reduced feeding costs when BSFL was incorporated into fish diets.

The use of BSFL also enabled some farmers to sustain fish production during periods of financial difficulty when commercial feeds were inaccessible. In addition, integration of BSFL with fish farming strengthened circular production systems. Some farmers in Kyaka II went ahead to integrate poultry production fed on BSFL and fish farming in the same loop. Organic waste was converted into valuable protein for poultry production and the poultry litter then converted into feed for aquaculture. This contributed to improved livelihood opportunities within the refugee and host community context.

A growing local market for BSFL has begun to emerge both within and around the Kyaka II refugee settlement. Farmers receive demand from fellow group members, neighbouring households, and livestock farmers within their villages who are not directly involved in insect production. Poultry and piggery farmers in particular have become important local buyers of fresh and dried larvae. In some cases, larger poultry farmers from neighbouring sub-counties and districts travel directly to the settlement to purchase BSFL.

Although the current market remains relatively small, localised, and fragmented, the overall outlook is highly promising. Demand for alternative protein feed ingredients continues to grow, while production volumes within the settlement are still relatively limited. However, as farmers continue expanding production capacity, there will be an increasing need to access larger and more structured markets beyond the settlement itself.

Future growth opportunities are likely to depend on linking BSFL producers to commercial feed processing companies, larger poultry farms, and aquaculture enterprises in major urban centres such as Kampala and Wakiso. Such linkages would help integrate refugee and host community farmers into Uganda's mainstream animal feed industry while significantly increasing the commercial viability of BSFL production.

Beyond larvae production itself, the emerging market for BSFL eggs and young larvae also presents an important business opportunity. Some farmers and commercial actors prefer purchasing eggs or starter larvae rather than managing the entire breeding cycle. This creates potential for specialised breeding enterprises capable of supplying reliable rearing stock to other producers.

The cooperative production model established under the project places Kyaka II farmers in a particularly strong position to take advantage of these emerging opportunities. Through collective organisation, farmers have already succeeded in improving access to organised waste streams from markets. These achievements are an inspiration and motivation for the farmers cooperative to push for more gains, including establishing linkages with mainstream feed markets.

9.2. Frass fertiliser

Another valuable product is the BSFL frass, which is a rich fertiliser that can boost vegetable production among refugees. To support vegetable production, the frass derived from black soldier fly rearing is converted into organic fertiliser by composting for five weeks to improve maturity and stability for field application. There is certainly potential for further developing the market for frass-based fertiliser.

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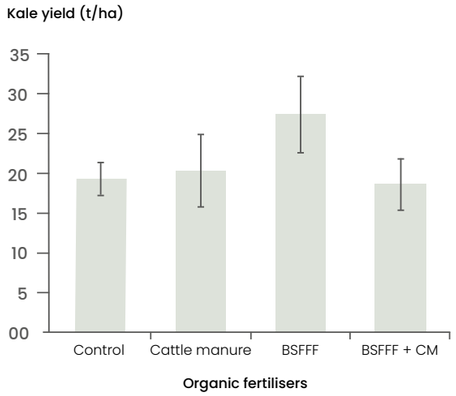
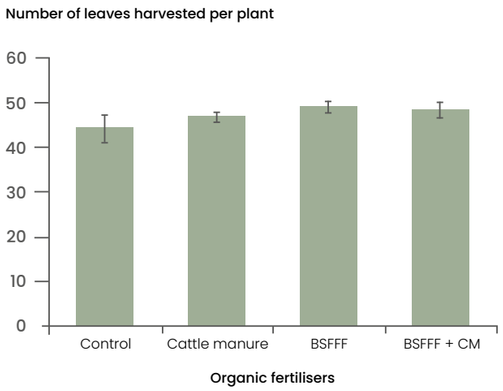
Agronomic trials carried out as part of RefIPro showed that the application of BSF frass fertiliser, either alone or in combination with cattle manure, enhanced kale height, leaf area, and number of leaves. This method improved kale yield by 35% compared to cattle manure alone, highlighting BSF frass's superiority for vegetable production. Figure 5 shows yield and number of leaves per plant for plants grown with no fertiliser (control), cattle manure, BSF frass fertiliser, and a combination of cattle manure and BSF frass fertiliser.

Figure 5: *Growth and yield parameters of kale grown in soil amended with BSF frass fertilisers, cattle manure, and their combinations.*





Households integrate BSFL rearing with vegetable production. BSFL production generates frass that can be composted and used as an organic fertiliser for vegetable production. RefIPro agronomic trials found that BSF frass improved kale growth and yield, demonstrating an additional benefit of insect farming beyond animal feed production.

10 . The business case for local BSFL production

Rapid urbanisation, rising incomes, and population growth in Uganda are driving an increase in demand for animal-source foods such as poultry, fish, pork, and eggs. This growth is creating significant pressure on the animal feed industry, particularly on the supply of protein-rich feed ingredients required to sustain expanding livestock production.

Conventional protein sources such as soybean meal and fishmeal are becoming increasingly expensive, environmentally unsustainable, and often inaccessible to smallholder farmers. Expansion of soybean production requires additional agricultural land, potentially encroaching on fragile ecosystems, while rising demand for silver fish and other fishmeal sources contributes to pressure on aquatic resources and risks of overfishing. These trends create a strong opportunity for alternative and more sustainable protein sources such as BSFL.

The RefIPro project strongly demonstrates that there is a promising and growing business case for local BSFL production in Uganda, particularly within refugee and smallholder farming contexts. Uganda's livestock sector – especially poultry farming, piggery, and aquaculture – continues to expand rapidly, increasing demand for affordable, high-quality feed ingredients. Yet feed costs remain one of the biggest constraints to livestock profitability, accounting for approximately 60-80% of total production costs, with protein ingredients contributing over 50% of these expenses. Affordable alternative protein sources are therefore critically important for improving the competitiveness and profitability of local livestock enterprises.

BSFL is a highly competitive alternative protein ingredient due to its high protein and fat content and its ability to partially replace fishmeal and soybean meal in poultry, pig, and fish feeds. Unlike conventional feed proteins, BSFL can be produced locally using organic waste streams readily available from markets, restaurants, households, and agro-processing activities. This not only lowers feed production costs but also contributes to improved waste management and environmental sanitation. Furthermore, BSFL farming requires relatively little land, water, and infrastructure, making it particularly suitable for refugee settlements and densely populated smallholder farming environments.

The market outlook for BSFL in Uganda is increasingly positive. Under the RefIPro project, both refugee and host community farmers successfully sold fresh and dried larvae directly to poultry, pig, and fish farmers within and beyond their communities, while also using part of the production for their own livestock enterprises. Some commercial poultry farmers from

“The RefIPro project strongly demonstrates that there is a promising and growing business case for local BSFL production in Uganda.

neighbouring districts travelled to the Kyaka II refugee settlement specifically to purchase larvae. Although the market remains relatively localised and fragmented, demand continues to grow steadily as awareness of BSFL as a viable feed ingredient expands.

Uganda's broader commercial feed industry also presents significant long-term opportunities. As production volumes increase and farmer cooperatives become more organised, BSFL producers can potentially supply larger institutional buyers such as feed manufacturers, hatcheries, and commercial poultry farms in urban centres including Kampala and Wakiso. The cooperative structures emerging within the Kyaka II refugee settlement provide an important foundation for the bulking production, quality assurance, processing, branding, and collective marketing necessary for accessing these larger markets.

Beyond larvae sales, additional business opportunities are emerging around BSFL eggs, young larvae (5-DOL), frass fertiliser, and organic waste collection services. These interconnected enterprises demonstrate that BSFL production is not merely a single farming activity, but part of a broader circular bioeconomy with strong potential for livelihood creation, food systems transformation, environmental sustainability, and inclusive local economic development.

In the RefIPro project, 25 farmers associations produced on average 150 kilos per group per month. At a market value of UGX 3,000 per kilo, this represented an average monthly value of UGX 450,000 per group. As each group had on average 20 members, the average value of the production per person per month was UGX 22,500.

As described above, the main constraints to increasing production were access to sufficient BSF eggs, sufficient waste, and sufficient capital to purchase production kits. If solutions are found to ease these constraints, each farmers association would easily be able to produce two to three times the current quantity with the space they already have available. As such, the value of the production per person could potentially increase to UGX 67,500 per month.

On the expenses side, there are in principle not high costs involved in producing BSFL. However, there are some expenses related to running breeding centres or purchasing BSF eggs from breeders, waste collection and sorting, purchase of maize bran and down payments on production equipment.

10 . Conclusions

Production of black soldier fly larvae holds great promise as a technology that can boost small-scale livestock production. It requires limited technical skills and limited investments and is therefore well suited to many refugee contexts.

BSFL holds most value for small-scale farmers already engaged in the production of poultry, pigs, or fish. While refugees without livestock can also gain some income from directly selling the larvae they produce, the larvae have much greater value for people who are able to use it to feed their own animals, which can then be sold at greater profits. BSFL should therefore mainly be seen as a way to utilise organic waste to produce a local, affordable, alternative to commercial animal feed.

This means that BSFL initiatives should first of all target refugees who are already producing poultry, pigs, or fish. Alternatively, support for BSFL production can be integrated as an add-on to initiatives that assist refugees in starting to rear their own livestock. In addition, the production of frass for vegetable or maize production is an important part of the BSFL production income-generation model.

Any initiative to introduce the production of black soldier fly larvae should start with the identification of local sources of organic waste. Ideally, there should be abundant suitable waste available very close to producers. Collection of organic waste from a wider area is a possibility, but the viability of this should be carefully examined, and should take into account the cost of transporting waste from sources to BSFL producers. Organic waste can be mixed with other types of feed, including cow dung. It may be worthwhile to combine freely available feeds with limited quantities of feeds that have to be purchased at cost, such as maize bran or wheat bran.

Fermentation is a promising pathway for opening up additional sources of freely available waste that is not used for other purposes. Relevant plant feed sources available in Western Uganda include banana pseudo stems and water hyacinth. Other locations may offer other sources of organic material suitable for BSFL production.

Another potential bottleneck for scaling up BSFL production is insufficient production of BSF eggs. Each individual farmer or farmers association should ideally be able to manage the whole life cycle and produce their own eggs. However, this can be combined with a centralised production facility which can sell eggs to farmers who are not yet able to produce their own eggs, as was the case in the RefIPro project.

Access to finance is also a likely constraint for ensuring the required investments to scale up production. BSFL production does not require very high investments, yet for refugees with very limited access to capital, finance can still be a significant barrier. Here, projects should support local savings and loans groups and Savings and Credit Cooperatives (SACCOs) that can provide more affordable credit. In addition, cooperatives of BSFL farmers can be supported to establish agro-dealer shops similar to other types of agricultural livelihood initiatives. These cooperative agro-dealer shops can supply the necessary inputs to BSFL farmers (mainly production kits, but potentially also eggs) based on forward contracts or on credit with payment in instalments, to be paid once the farmer starts earning income from BSFL production. Such initiatives can also serve to make the cooperatives financially sustainable.

Finally, an important lesson from the RefIPro project is that supporting BSFL farmers to work together in farmer's associations and cooperatives can support peer learning, facilitate the pooling of resources, and strengthen the position of farmers to advocate for support from governments. An additional advantage specifically in the refugee context is that these associations can bring together refugees and host community members to work together towards common goals.

BSFL provides smallholder farmers with a cheaper feed alternative for pig rearing units. This protein source reduces reliance on expensive conventional feeds and strengthens the livestock production.

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