CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS
a UNEP convened initiative

CREATING OPPORTUNITIES FOR BLACK SOLDIER FLY (BSF) WASTE PROCESSING

A POLICY GUIDE FOR GOVERNMENTAL ACTORS

October 2025

Africa Circular · eawag aquatic research · ECLOSE We help you fly · CARBON TURNAROUND · PREVENT Waste Alliance

Suggested citation: Climate and Clean Air Coalition (2025). Creating opportunities for Black Soldier Fly (BSF) waste processing: A guide for governmental actors. Paris.

Production: Paris

URL: https://www.ccacoalition.org/projects/biomass-utilisation-insects-green-solutions-africa;

Acknowledgments

Contract details

This document was developed in the framework of the Biomass Utilisation By Insects For Green Solutions In Africa (BUGS-AFRICA) project funded by Climate and Clean Air Coalition (CCAC) and the Sustainable Waste-based Insect Farming Technologies (SWIFT) project funded by Solution-Oriented Research for Development Programme (SOR4D), Grant Nr. 400440_213241/1).

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Rotterdam, 30/09/2025

Executive summary

Africa stands at a critical juncture, grappling with escalating challenges in organic waste management, the impacts of climate change, and persistent socio-economic disparities, particularly concerning youth unemployment and gender inequality. Uncontrolled organic waste streams are not only a burgeoning environmental and public health hazard but also a significant contributor to greenhouse gas emissions, notably methane. This policy report presents the Black Soldier Fly (BSF) solution as a compelling, sustainable, and economically viable solution to address these multifaceted issues, with a specific focus on its application and policy implications in Uganda, Ethiopia, and Cote d'Ivoire.

The report rigorously details how BSF bioconversion offers a truly transformative approach to organic waste management. By efficiently diverting vast quantities of diverse organic waste – ranging from agricultural residues to food scraps – from landfills and open dumps, BSF cultivation directly and significantly contributes to climate change mitigation through the prevention of potent methane emissions. This process is central to fostering a robust circular economy, converting what was once considered valueless waste into high-value resources. The primary outputs, protein-rich BSF larval meal and fat, provide a sustainable, locally-produced alternative to expensive, often imported, conventional animal feed ingredients like fishmeal and soy meal, thereby bolstering food security and reducing import dependencies. Concurrently, the nutrient-dense BSF frass, the residual byproduct, serves as an effective organic soil conditioner and bio-fertilizer, promoting vital soil health, improving crop yields, and reducing reliance on synthetic chemical inputs.

Beyond these profound environmental and economic advantages, BSF uniquely addresses critical socio-economic challenges. The inherent flexibility and low-tech entry points of BSF farming create accessible and scalable entrepreneurship opportunities, particularly for women, enabling them to gain financial independence, build new skills, and contribute meaningfully to household incomes. For youth, BSF offers dynamic avenues for green job creation and skill development, providing attractive alternatives to traditional or informal sector work and helping to curb rural-urban migration. The continent's tropical and subtropical climates further amplify BSF's financial viability, significantly reducing the need for costly, energy-intensive climate control systems (such as heating, cooling, or humidifying) often required in other regions, which directly lowers initial capital expenditure (CAPEX) and ongoing operational costs (OPEX) for BSF facilities.

Achieving widespread and successful BSF implementation necessitates a concerted effort spanning robust policy support and collaborative action across various stakeholder groups.

Key recommendations put forth in this report include:

- **Establish clear legal and regulatory frameworks:**
  Formalize BSF and its products as valuable products. This foundational step removes legal ambiguity and reduces investor risk. Investment is needed to fund science-based research to inform regulations and to establish testing and certification bodies.

- **Integrate BSF into national waste management strategies and NDCs:**
  Explicitly include BSF bioconversion in national waste and climate policies, as well as in Nationally Determined Contributions (NDCs). This official recognition attracts international climate finance and signals a country's commitment to climate action.
- **Implement financial incentives and support mechanisms:**
  Create a supportive financial environment in the short term. Implement policies that allow BSF facilities to charge waste acceptance fees and establish dedicated funding streams like grants, subsidies, or tax breaks. Investment is needed to set up these financial instruments.
- **Support local government implementation:**
  Empower local authorities on the front line of waste management. In the next 1–3 years, invest in providing financial and technical assistance directly to municipalities. This builds local capacity and confidence in BSF technology.
- **Prioritize targeted Research and Development (R&D)**
  Invest in localized R&D to adapt BSF technologies to specific African contexts. This includes funding collaborations with local universities to evaluate locally available feedstocks and develop low-cost, manufacturable technologies. This ensures the sector is built on a strong, local foundation.

Ultimately, by embracing the BSF solution, African nations can significantly enhance their national climate ambitions, directly contributing to Nationally Determined Contributions (NDCs) through tangible methane reductions. This positions BSF as a powerful tool for achieving multiple Sustainable Development Goals (SDGs), fostering resilient local economies, improving food and resource security, and building a greener, more prosperous, and equitable future across the continent. This policy guide serves as a foundational roadmap for policymakers and practitioners to realize this transformative vision.

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List of abbreviations

AD	Anaerobic Digestion
BSF	Black Soldier Fly
BSFL	Black Soldier Fly Larvae
C	Carbon
CAPEX	Capital Expenditure
CBO	Chief Biology Officer
CCAC	Climate and Clean Air Coalition
CEO	Chief Operating Officer
CH_4	Methane
CO_2	Carbon Dioxide
COO	Chief Operating Officer
CP	Crude Protein
FCR	Feed Conversion Rate
GHG	Green House Gas
GWP	Global Warming Potential
$GtCO_2e$	Gigatonnes of CO2 equivalent
HFC	hydrofluorocarbons
HVAC	Heating, Ventilation and Air Conditioning
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
M&E	Monitoring and Evaluation
MoU	Memorandum of Understanding
MRV	Measurement, Reporting, and Verification
MSW	Municipal Solid Waste
Mt	Million Tonnes
N	Nitrogen
N_2O	Nitrous Oxide
NDC	National Determined Contribution
NGOs	Non- Governmental Organization
NPK	Nitrogen, Phosphorus, Kali
OPEX	Operating Expenditure
PPP	Public Private Partnership
R&D	Research & Development
ROI	Return on Investment
SDG	Sustainable Development Goals

SLCPs	Short Living Climate Pollutants
SMART	specific, measurable, achievable, relevant, and time-bound
SME	Small and Medium Size
SWOT	Strength, Weakness, Opportunity, and Threat
VCS	Voluntary Carbon Standard
VOC	volatile organic compound

Setting the context

1 Setting the context for this BSF policy guide

1.1 Aim and objectives of this BSF policy guide

This Black Soldier Fly (BSF) Policy Guide is crafted as a to support and empower a diverse array of public actors with the essential knowledge to understand the approach and the required enabling environment, in order to develop and implement strategies and policies, and actively promote BSF technology locally and across the African continent. The overarching aim is to promote the BSF's solutions as an environmentally sustainable and economically viable alternative for integrated organic waste management in the target countries, thereby contributing profoundly to broader development challenges and objectives across the region. This comprehensive guide seeks to proactively bridge existing knowledge gaps and dismantle pervasive misconceptions. By doing this, public actors and key stakeholders will thus possess the knowledge and tools, to actively catalyze concerted action towards harnessing the full, transformative potential of BSF for significant societal advancement and profound environmental benefit, ultimately contributing directly and substantially to national development priorities and international sustainability commitments.

This guide aims to highlight the often-underestimated potential of BSF technology. Many, from policymakers to the public, lack a full understanding of its benefits.

BSF solutions are technically viable and efficiently treat organic waste. They offer significant environmental benefits, including reduced greenhouse gas emissions and pollution prevention. Moreover, BSF technology provides considerable socio-economic advantages, such as job creation, improved food security, and diversified income.

A central objective of this guide is to raise awareness about the immense, often underestimated, potential of BSF technology. Many stakeholders, from policymakers to the public, currently lack full understanding of BSF solutions and their benefits. The guide outlines BSF's technical viability, efficient organic waste treatment, and profound environmental (GHG reduction, pollution prevention) and socio-economic (job creation, food security, income diversification) advantages. By countering doubts with compelling arguments, it aims to build political will, public acceptance, and robust private sector engagement. This is crucial for widespread BSF adoption and sustainable growth, transforming organic waste from a liability into a valuable resource for local circular economies.

Furthermore, this guide offers clear, actionable advice to enable widespread BSF adoption and scaling across Africa. Sustainable implementation requires a comprehensive, supportive ecosystem, beyond just technical know-how. This includes supportive and coherent policy and regulatory landscapes, accessible and appropriate financing mechanisms, strong institutional support, and robust market linkages. The guide systematically identifies critical policy, regulatory, financial, and institutional reforms essential for a growing and sustainable BSF sector. It outlines practical steps for governments, development partners, and other stakeholders to create an enabling environment where BSF ventures—from small-scale to large-scale—can flourish as viable alternatives for organic waste management. This covers streamlining permitting, establishing clear quality standards for BSF products (feed, fertilizer), facilitating equitable access to green financing, and fostering dynamic public-private partnerships for growth and scale.

This guide equips governments to assess BSF projects, adapting regulations and outlining proactive legislative, fiscal, and capacity-building measures. These are crucial to strengthen the BSF value chain, from waste collection to product commercialization.

Crucially, the guide provides concrete, actionable policy recommendations and a practical roadmap for widespread BSF implementation and scaling. These pragmatic strategies facilitate seamless BSF integration into national waste management and economic frameworks. This includes embedding BSF in national waste management strategies, aligning with NDCs for GHG reduction, enhancing agricultural policies via sustainable feed and fertilizer, and supporting broader national development agendas.

The roadmap offers a structured, phased approach for stakeholders, guiding from feasibility and pilot projects to nationwide scaling and comprehensive value chain development (feedstock to market). This strategic guidance ensures coordinated, impactful, and sustainable efforts, unlocking BSF's full transformative potential across Africa. It significantly contributes to national development priorities resource-efficiently, responsibly, and inclusively. While designed for Cote d'Ivoire, Uganda, and Ethiopia, its content is applicable across the entire African region to promote BSF's long-term success and widespread replication.

The overall organic waste problems and situation in Africa are summarized in the ANNEX of this document.

1.2 BSF opportunities for development challenges in Africa

The BSF biowaste conversion offers a multifaceted approach to addressing several pressing development challenges across Africa. Its inherent biological capabilities provide a unique opportunity to foster sustainable organic waste management, mitigate climate change, promote circular economy principles, and unlock significant socio-economic benefits, including enhanced food security and improved soil health.

1.2.1 Organic waste management: Efficient reduction and stabilization

A primary advantage of BSF technology lies in its remarkable capacity for efficient organic waste management. BSF larvae are highly effective bio-converters, consuming diverse organic substrates like food waste, agricultural residues, and manure. This process significantly reduces waste volume (up to 70% or more), transforming it into valuable insect protein, insect oil, and nutrient-rich organic fertilizer. Diverting large quantities from landfills prevents putrescible matter accumulation, stabilizing waste and reducing public health risks (disease vectors, odors). This provides a sustainable, environmentally sound alternative to conventional waste disposal.

1.2.2 Climate change mitigation: Significant reduction of methane emissions

The implementation of the BSF technology contributes directly and substantially to global climate change mitigation efforts by reducing GHG emissions through multiple pathways. Firstly, BSF bioconversion facilitates a significant reduction of direct methane (CH_4) emissions. Organic waste, when undergoing anaerobic decomposition in unmanaged dumpsites and landfills, produces methane, a potent greenhouse gas with a global warming potential of around 28 times higher over a time horizon of 100 years than carbon dioxide (CO_2).[1] By diverting this organic waste from anaerobic environments and processing it aerobically using BSF larvae, the generation of methane is largely avoided. Studies indicate that diverting one tonne of organic waste from landfilling can prevent the emission of approximately 0.5–3 tonnes of CO_2e emissions when compared to unmanaged organic waste dumping under anaerobic conditions.[2]

[***Note***: *Methane emissions from landfilled organic waste are very context depended and can vary considerable. Influencing factors are type of organic waste, climate conditions, depth of landfill, among others.*]

This direct prevention of methane release makes BSF a valuable tool for reducing short-lived climate pollutants (SLCPs), thereby contributing to rapid and tangible climate benefits.

Secondly, the application of BSF technology leads to additional potential emission avoidance through the valorization of its by-products and their substitution for conventional resources.

Use of the frass avoids emissions from chemical fertilizer production. BSF frass, the residual material after larval digestion, is a nutrient-rich organic fertilizer.[3] Its utilization in agriculture can reduce the demand for synthetic chemical fertilizers. The production and transport of these conventional fertilizers are energy-intensive processes, and their production and use lead to direct emissions of nitrous oxide (N_2O), another potent greenhouse gas.[4] In 2018, the synthetic nitrogen (N) fertilizer supply chain was responsible for an estimated 1.13 $GtCO_2e$ emissions, accounting for 10.6% of agricultural emissions and 2.1% of global greenhouse gas emissions.[5] Using frass as a substitute, indirectly contributes to a reduction in these associated GHG emissions.

Use of larvae as animal feed reduces the need for conventional animal feed and therefore reduces emissions from production of the conventional animal feed. BSF larval meal provides a sustainable, protein-rich alternative to conventional animal feed ingredients such as fishmeal

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[1] https://www.ccacoalition.org/short-lived-climate-pollutants/methane.

[2] EPA (2023). Quantifying Methane Emissions from Landfilled Food Waste.

[3] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

[4] Lawrence, N.C., et. al. (2021). Nitrous oxide emissions from agricultural soils challenge climate sustainability in the US Corn Belt.

[5] Menegat, S., Ledo, A. & Tirado, R. (2022). Greenhouse gas emissions from global production and use of nitrogen synthetic fertilisers in agriculture.

and soy meal. The production of these traditional feed components are connected to substantial GHG footprints. For instance, fishmeal production involves fuel consumption for fishing vessels, while soy cultivation can be linked to land-use change, deforestation, and emissions from agricultural practices, including N_2O from fertilizer use. For example a study for Brazilian soy bean concluded average GHG emissions during three crop years of 0.186 kg of CO_2eq kg of soybean produced.[6] By replacing a portion of these conventional feeds in animal diets, BSF larval meal helps mitigate the emissions associated with their production chains.

In summary, BSF technology offers a dual climate change mitigation benefit: direct methane reduction from waste diversion and indirect GHG emission avoidance through the substitution of emissions-intensive conventional fertilizers and animal feeds. These contributions are significant for reducing short-lived climate pollutants and enhancing National Determined Contributions (NDCs) towards global climate goals.

1.2.3 Circular economy: Production of valuable byproducts

BSF technology embodies circular economy principles by transforming waste into valuable resources. The bioconversion yields two primary byproducts: BSF larval meal and BSF frass. While small facilities generally don't defat the larval meal, large-scale operations can extract insect oil, creating a third saleable product.

Larval meal, rich in protein and fat, is a sustainable, high-quality animal feed ingredient for aquaculture, poultry, pigs, and even pets. This closes nutrient loops and reduces reliance on conventional feed. BSF frass, the residual material after digestion, is a nutrient-rich organic fertilizer directly applicable to soil. It returns essential macro and micronutrients to agriculture, enhancing soil fertility. This integrated approach minimizes waste, creates value, and fosters sustainable resource management.

1.2.4 Economic opportunities: Job creation and income generation

Establishing and scaling BSF operations unlock significant economic opportunities across the value chain. The sector has potential to create diverse jobs, from low-skilled waste sorting to skilled facility management and product development. For local communities, particularly in rural and peri-urban areas, BSF initiatives provide new avenues for income generation, contributing to poverty alleviation and improved livelihoods. Local BSF enterprises also stimulate economies by fostering linkages within agricultural and waste management sectors.

1.2.5 Food security: Sustainable protein source for animal feed

In Africa, BSF offers a sustainable, locally producible animal protein source for growing demands. BSF larval meal provides an excellent alternative to conventional feeds like fishmeal and soybean meal, whose production often carries significant environmental footprints (e.g. overfishing, deforestation) and volatile markets. By producing high-quality protein locally, BSF

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[6] Silva Raucci, G., et al. (2015). Greenhouse gas assessment of Brazilian soybean production: a case study of Mato Grosso State.

reduces import reliance, stabilizes feed costs for livestock farmers, and contributes to national food system resilience. This innovation directly supports food security by providing a reliable, environmentally friendly protein source for Africa's rapidly expanding aquaculture and poultry sectors.

1.2.6 Soil health: Nutrient-rich frass as biofertilizer

The BSF frass byproduct is a potent organic fertilizer that significantly contributes to soil health. Rich in essential plant nutrients (nitrogen, phosphorus, potassium) and organic matter, frass can improve soil structure, water retention, and microbial activity. Its application reduces the need for synthetic chemical fertilizers, which can be expensive for smallholder farmers and contribute to environmental pollution through runoff. By promoting the use of BSF frass, the solution supports regenerative agricultural practices, enhances soil fertility over the long term, and fosters more sustainable farming systems across Africa.

1.2.7 Reduced land use: Efficient protein production

BSF protein production offers a highly land-efficient alternative to traditional protein sources. Unlike conventional agriculture, which requires vast tracts of land for cultivating crops like soybeans for animal feed, BSF larvae can be reared in vertical systems within relatively small footprints. This intensive production method means that significantly less land is needed to produce the same amount of protein, thereby reducing pressure on natural ecosystems, preventing deforestation, and preserving biodiversity. This efficiency makes BSF an attractive option for land-scarce regions or for countries looking to optimize agricultural land use.

1.2.8 Gender & climate: Inclusive development and resilience

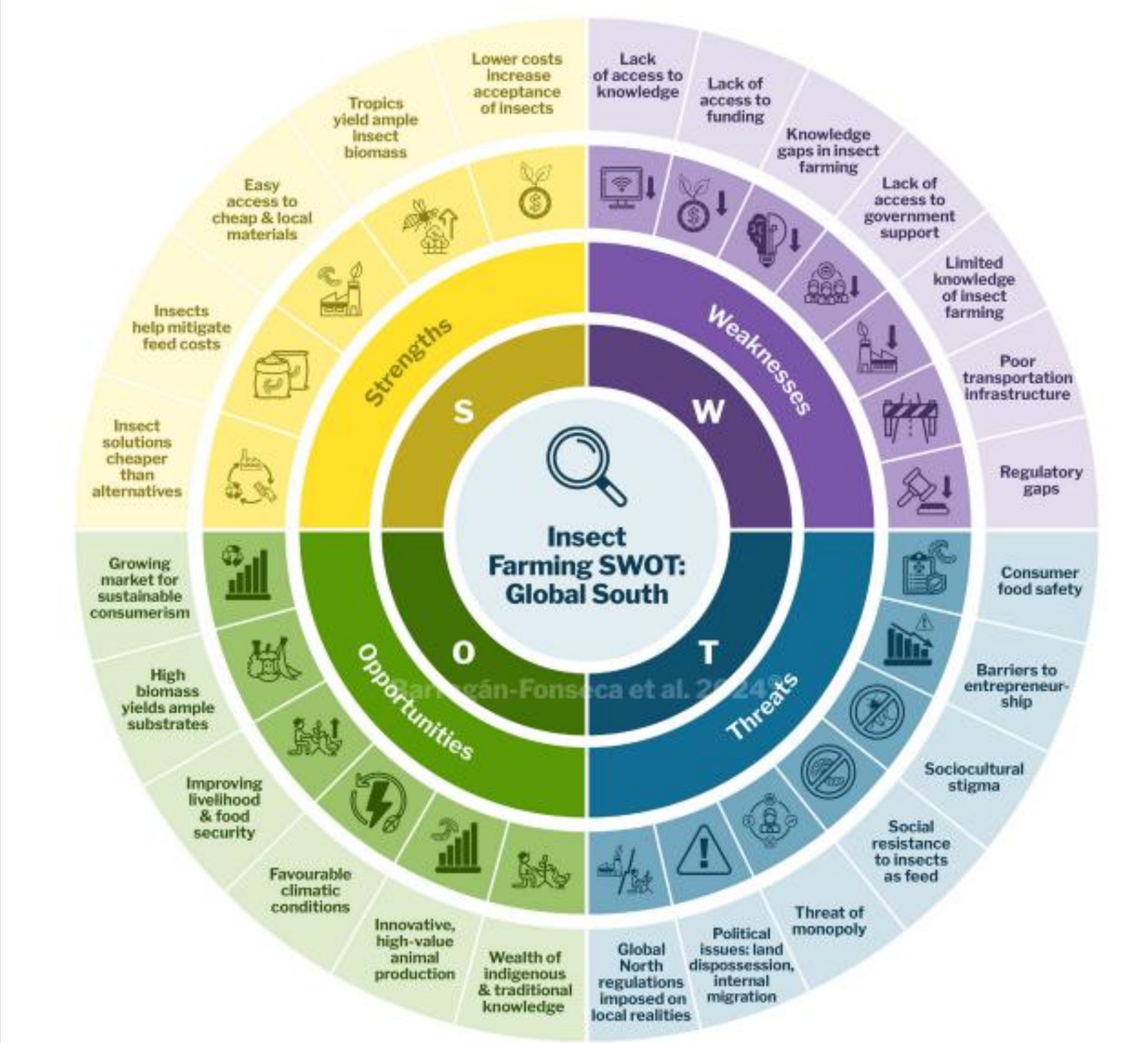
The BSF sector presents unique opportunities for gender and youth empowerment, contributing to more inclusive development and enhanced climate resilience. For women, BSF farming offers pathways to entrepreneurship, financial independence, and leadership in community waste management and food security initiatives. For youth, the BSF industry offers innovative, green employment and entrepreneurship, equipping them with valuable skills in biotechnology, waste management, and sustainable agriculture. By actively engaging women and youth, BSF solutions build a more diverse and resilient workforce capable of driving sustainable development and climate action across Africa.

1.3 BSF SWOT Analysis for countries in the Global South

The BSF solution especially for countries in the Global South, offers an interesting opportunity due to a couple of advantages compared to projects in the Global North. Nevertheless, there are also some challenging factors which projects in the Global South are confronting.

The following Figure 1-1 is giving a detailed SWOT analysis for BSF projects in countries in the Global South. As this figure shows, there are many aspects, which have to be considered. This guide focuses on the weaknesses and threats for BSF projects in such countries, which are highlighted in this SWOT analysis in order to overcome these challenges to support the development of a flourishing BSF sector.

Figure 1-1 Analysis of strengths, weaknesses, opportunities, and threats of insect farming in the Global South



Source: Barragán-Fonseca, K.B., et al. (2024). Review – Insect farming for food and feed in the Global South: Focus on black soldier fly production.

1.4 Comparative impact of protein sources

The increasing global demand for animal protein has placed immense pressure on conventional feed ingredients, primarily soybean meal and fishmeal. A comparative analysis of their environmental and societal impacts against emerging alternatives like insect protein (specifically BSF) reveals significant differences across various sustainability metrics, driving the impetus for adopting more circular and eco-friendly solutions.

1.4.1 Soybean meal: land use, soil, and water intensity

Soybean production, a dominant source of protein for animal feed globally, is often associated with substantial environmental footprints, particularly in key producing regions such as South America.

- Land use change: A primary concern is its strong link to deforestation and habitat conversion, especially in sensitive ecosystems like the Amazon rainforest and Cerrado biome in South America, leading to significant biodiversity loss.
- Soil impact: Intensive monoculture farming practices can lead to soil degradation, erosion, and nutrient depletion, necessitating high inputs of synthetic fertilizers.
- Climate impact: While the direct GHG emissions per kg of soybean protein can be lower than some animal proteins, the indirect emissions from land use change (e.g., loss of carbon sinks from deforestation) can be substantial.
- Water need: Soybean cultivation is highly water-intensive, particularly when relying on irrigation, which can exacerbate water scarcity in certain regions.
- Pollution: The extensive use of pesticides and herbicides in conventional soybean farming can lead to water and soil pollution, impacting local ecosystems and human health.

1.4.2 Fishmeal: marine resource pressure and biodiversity concerns

Fishmeal, a high-quality protein source, is primarily derived from wild-caught fish, often small pelagic species. Its environmental impact is fundamentally tied to marine ecosystem health:

- Biodiversity impact: Overfishing of target species and significant bycatch (unintended capture of non-target marine life, including endangered species like dolphins, turtles, and seabirds) exert immense pressure on marine biodiversity and ecosystem balance.
- Resource depletion: The demand for fishmeal contributes to the depletion of wild fish stocks, threatening the sustainability of marine fisheries and the livelihoods of coastal communities dependent on them.
- Climate impact: While not linked to land-use change, industrial fishing operations contribute to GHG emissions through fuel consumption of fishing vessels and processing operations.
- Pollution: Fishing gear lost or discarded at sea (ghost fishing) continues to capture marine life indefinitely, while waste and chemical runoff from fishmeal processing plants can contribute to localized marine pollution.

1.4.3 Insect protein (BSF): Circularity and reduced environmental footprint

BSF larvae offer a compelling alternative by converting organic waste into valuable protein and other co-products, embodying circular economy principles. The environmental advantages of BSF protein, especially when reared on organic waste, are notable:

- Waste generation: Instead of generating waste, BSF systems act as waste valorization platforms, reducing the volume of organic waste destined for landfills by up to 80%, thereby mitigating methane emissions from decomposition.

- Climate impact: By diverting organic waste from anaerobic decomposition in landfills, BSF cultivation significantly reduces methane emissions. The overall carbon footprint of insect protein, especially when larvae are fed on food waste, can be considerably lower compared to conventional protein sources.
- Land use change: BSF farming requires minimal land, often utilizing vertical or modular systems, and does not contribute to deforestation or agricultural land expansion, making it highly land-efficient.
- Water need: The water footprint of BSF production is significantly lower than that of soybean or conventional livestock, as much of the moisture for larval growth comes directly from the organic waste feedstock.[7]
- Nitrogen needs and impact: BSF efficiently recycle nutrients, including nitrogen, from organic waste into their biomass and the residual frass. This reduces the need for synthetic nitrogen fertilizers in subsequent agricultural applications when frass is used, thereby lessening nitrogen runoff and associated environmental impacts.
- Biodiversity impact: Unlike fishmeal, BSF production does not exert pressure on wild fish stocks or marine ecosystems. Unlike soy, it does not drive deforestation for agricultural expansion, thus having a positive or neutral impact on natural biodiversity.
- Pollution: BSF systems, when properly managed, can reduce water and soil pollution by preventing organic waste leachate and run-off associated with traditional waste disposal sites. The frass produced is a valuable soil amendment, avoiding the pollution associated with synthetic fertilizers.

[7] Smetana, S. et al. (2023). Environmental impact potential of insect production chains for food and feed in Europe.

Figure 1-2 summarises the comparison of these three animal feed protein sources.

Figure 1-2: Broad environmental impact comparison between soybean, wild fish, and insect protein meal

Impacts		Soybean	Wild Fish	Insect
State Indicators (changes to state of nature)				
Land Use change		High conversion risk	No impact	No land use change at scale
Soil condition		Intensive agriculture	No impact	No impact
Climate impact		Conversion	Relatively low emissions from shipping	Operation of facility
Water removed		If irrigated	Low impact	Operation of facility and substrate moisture adaption
Nitrogen		If N fertilizer is applied to soy or to through crop rotation	No impact	Nitrogen accumulation in frass
Biodiversity		Conversion and intensive agriculture	Reduced fish stocks and bycatch	Low ecological impact
Pollution		Pesticide used and eutrophication	Effluent discharge	Limited evidence
Waste		Limited evidence	Limited evidence	By-products chitin and frass have uses and growing market
Pressure indicators (environmental footprint assessment				
Land use footprint		Large area required	Small area used	Small area used
Carbon footprint	Direct	Cultivation and shipping	Fishing vessels	Heating requirement
	Indirect	Land use change	Low indirect footprint	Substrate dependent
Water footprint		High water use	Limited evidence	Low water use

Source: GreenCape (2023). Industry Brief: Black Soldier Fly agriculture - Upcycling Cape Town's organic waste into local, climate friendly, and resilient feed for livestock, pets and the soil.

1.5 Barriers for increased adoption of the BSF solution for organic waste management in Africa

Despite the multiple advantages of the BSF solution, its widespread adoption for organic waste management in African countries, including target nations like Cote d'Ivoire, Uganda, and Ethiopia, currently faces a range of significant barriers. Addressing these challenges is important for unlocking the full potential of BSF solutions across the continent. This chapter is giving an overview about the most relevant aspects why the BSF solution is facing barriers for its large-scale adaptation as organic waste management solution.

1.5.1 Low awareness of BSF's potential

A fundamental barrier to BSF adoption in Cote d'Ivoire, Uganda, and Ethiopia is the widespread lack of awareness regarding its transformative potential. Many public actors, policymakers, and even waste management professionals are simply unaware of BSF technology as a viable, sustainable, and economically beneficial solution for organic waste. This knowledge gap extends to its environmental benefits, such as significant GHG emission reductions, and its economic opportunities, like generating valuable protein feed and biofertilizer. Without a clear understanding of what BSF is and what it can achieve, it remains challenging to garner the necessary political will, public support, and investment for its widespread implementation.[8]

1.5.2 Limited institutions and government extension services enabling circularity for organic waste management

Effective BSF solutions require a supportive institutional environment aligned with circular economy principles. In many African contexts, including target countries, waste, agriculture, and environmental institutions often operate in silos. Limited dedicated agencies or cross-sectoral platforms for organic waste circularity exist, hindering coordinated efforts and slowing BSF policy reforms.

A significant gap in the BSF value chain (e.g. Cote d'Ivoire, Uganda, Ethiopia) is the absence of dedicated government extension services. Unlike established agriculture, no formal programs disseminate BSF knowledge, technical assistance, or training. This lack of government-backed support critically impedes widespread adoption, limiting crucial information and best practices to producers. Without this vital bridge, broad-scale knowledge sharing is hampered, leaving many unable to confidently initiate or scale BSF operations.

1.5.3 Weak policy framework or inconsistency of policies

The absence of robust, coherent, and consistent policy frameworks poses a significant hurdle. In Cote d'Ivoire, Uganda, Ethiopia and in other countries on the African continent, existing waste management policies may not explicitly integrate or prioritize organic waste separation and treatment, nor do they often recognize insect farming as a legitimate and desirable industry. Where policies exist, they might be fragmented, inconsistent across different government levels (national, regional, local), or poorly enforced. This lack of clear regulatory guidance creates uncertainty for potential investors and operators, making it difficult to establish and scale BSF operations with confidence in the long-term policy environment. This overlap of regulatory bodies also is creating a grey area, leading most producers to operate informally and without guiding policies or regulations.

1.5.4 Unmature business models for the private sector

For BSF solutions to scale beyond pilot projects, viable and attractive business models for the private sector are essential. However, in our target countries, these models are often nascent or unproven. Challenges include difficulties in consistently securing sufficient quantities of segregated organic waste feedstock, establishing stable markets for BSF products (larval meal, frass, insect oil), and demonstrating profitability. Potential investors and banks perceive high risks due to this immaturity, leading to limited private sector engagement. The lack of standardized operating procedures and reliable data on return on investment further complicates the development of robust business cases.

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[8] Africa Circular (2025). Black Soldier Fly Opportunities Explored in Uganda, Ethiopia, and Ivory Coast.

1.5.5 Limited know-how, technological solutions and BSF processing services

Successful large-scale BSF operations require specific technical know-how and appropriate technology. In target countries (Cote d'Ivoire, Uganda, Ethiopia), local expertise is often lacking in optimal BSF rearing, waste pre-treatment, processing, and quality control. Access to suitable industrial equipment is also challenging and expensive, hindering efficient, sustainable facility operation.

A significant barrier to scaling BSF production is the absence of accessible, affordable processing services for larvae. Communal drying facilities and cost-effective solutions are vital to extend shelf-life and increase BSF product use. Compounding this, small-scale African producers particularly lack crucial aggregation and centralized processing services, impacting their ability to meet consistent, large volume demands from off-takers. Current dried BSF larval prices are also often uncompetitive for feed millers. These combined processing, aggregation, and pricing gaps limit market access and hinder the BSF industry's growth and professionalization.

1.5.6 Overcoming cultural resistance to use insects as animal feed

Despite the nutritional benefits of insect protein, there can be cultural perceptions or resistance to the idea of using insects as animal feed, especially for livestock intended for human consumption. This barrier, though potentially less pronounced in regions with existing insect consumption traditions, still requires careful communication and public education strategies in all target countries. Ensuring product acceptance by farmers and consumers is critical for establishing a sustainable market for BSF larval meal.

1.5.7 High cost, low returns, and limited access to capital

Initial investment costs for medium to large-scale BSF facilities are substantial, covering infrastructure, technology, and setup. While growing, the BSF market may offer delayed returns due to undeveloped supply chains or inconsistent quality. This combination of high upfront costs and limited access to appropriate financing (e.g. green loans, grants) creates a significant financial barrier for investors.

A key gap is the lack of readily available financial services. Banks and investors often view the BSF industry as high-risk given limited proof of concept, hindering essential capital for upscaling and professionalization. This challenge is compounded by the "donor darling approach," concentrating limited financing among a few recipients. This stifles broader innovation and sector-wide scale by making capital access difficult for most promising entrepreneurs.[9]

[9] FAO (2023). Mapping of the Black Soldier Fly value chain in East Africa.

1.5.8 Administrative burdens

Complex bureaucracy significantly impedes BSF project scaling, with permit challenges, lengthy approvals, and inconsistent regulations increasing costs and discouraging investors in target countries. Streamlining these processes is vital.

Adding to this, most small-scale BSF farmers operate informally, lacking crucial quality control for rearing substrates and finished BSF products.

1.5.9 Informal sector and immature BSF value chain

The informal waste management sector in African cities presents both a challenge and an opportunity for BSF integration. While crucial for waste collection, their unregulated operations often hinder BSF producers from securing consistent, high-quality organic waste. Formalizing and integrating these actors, recognizing their expertise and providing training, is essential for sustainable waste sourcing.

The BSF value chain itself remains largely immature, especially in Uganda, Ethiopia, and Cote d'Ivoire. Relationships between actors are often informal, and a central coordinating body or platform for dialogue is largely absent. This critical coordination gap necessitates a sectoral association to foster collaboration and shared growth.

Challenges also stem from the BSF value chain's novelty. Sales are low due to inconsistent quality/quantity and uncompetitive prices. Farmers often lack essential inputs (equipment, financing, knowledge, quality parent stock). This widespread lack of awareness and technical know-how, coupled with persistent waste management and sorting challenges, impedes sector development. Ultimately, absent specialized services and robust cooperation prevent the sector from realizing its full potential.

1.5.10 Lack of specialization along the BSF value chain

The BSF value chain requires specialized skills and businesses at each stage. In target countries (Cote d'Ivoire, Uganda, Ethiopia), this specialization is often lacking. Entrepreneurs manage the entire chain, leading to inefficiencies or gaps in feedstock and markets. This fosters internal competition, undermining collaboration and hindering market linkages. Fostering specialization and a mature ecosystem of diverse businesses is crucial for scale and efficiency, a trend already seen in Kenya's more mature BSF sector.[10]

1.5.11 Limited capacities of BSF products

Despite growing recognition, limited BSF product capacities significantly impede widespread adoption and full potential across Africa. The remarkably low volume of protein-rich larval meal and nutrient-dense frass produced and traded fundamentally obstructs developing a robust, mature BSF value chain, including in Uganda, Ethiopia, and Cote d'Ivoire.

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[10] FAO (2023). Mapping of the Black Soldier Fly value chain in East Africa.

This low supply creates a self-reinforcing barrier to market maturation. BSF production largely remains at pilot or SME scale, insufficient for larger commercial buyers. Major feed manufacturers and large agricultural enterprises require consistent, high-volume supplies to integrate BSF products. Inconsistent supply deters these established players, stifling broader market development and limiting opportunities for smaller BSF producers.[11]

The scarcity of supply profoundly hinders stable pricing mechanisms and transparent market infrastructure for BSF products. Without a critical mass, prices remain volatile, and efficient trade, quality verification, and standardized contracting are slow to emerge. This uncertainty discourages significant investment from producers and potential off-takers, who require predictable costs and guaranteed availability. The inability to consistently meet demand at a commercial scale also prevents achieving economies of scale in processing, logistics, and distribution, keeping unit production costs high. This challenges market penetration and competitiveness against conventional feed and fertilizer options, particularly in countries like Uganda, Ethiopia, and Cote d'Ivoire where input costs are critical for agricultural profitability.[12]

Limited BSF production capacity directly impacts broader value chain maturation. A truly thriving chain requires specialization and robust linkages among diverse actors, but low volume impedes the emergence of specialized processing, economically justified logistics, and large-scale R&D. This absence of critical mass keeps essential services and infrastructure underdeveloped, perpetuating a cycle where low production prevents market development, and underdeveloped markets disincentivize increased production. The absence of established frass distribution channels also restricts its uptake by smallholder farmers.

Ultimately, limited BSF product capacities significantly impede the industry's ability to demonstrate its full economic viability and scalability. This limits its appeal to larger investors and hinders its seamless integration into established agricultural and waste management systems that require scale and reliability. Overcoming this hurdle necessitates strategic interventions focused on supporting producers to scale up operations, facilitating robust and transparent market linkages, and establishing clear quality and safety standards. This will pave the way for a flourishing BSF value chain, making a substantial contribution to local economies and helping comply with climate mitigation targets in Uganda, Ethiopia, Cote d'Ivoire, and beyond.

1.5.12 Research gaps

While the research literature on BSF is considerable and continues to grow at a rapid pace, certain areas still require further exploration. There is a gap between theoretical research outcomes and research which is supporting practical challenges of BSF farmers and entrepreneurs.

The following identified research gaps are of special relevance for promoting enabling environments for further BSF uptake:

[11] FAO (2013). The contribution of insects to food security, livelihoods and the environment.
[12] Tanga, C.M. & Kababu, M. (2023). New insights into the emerging edible insect industry in Africa.

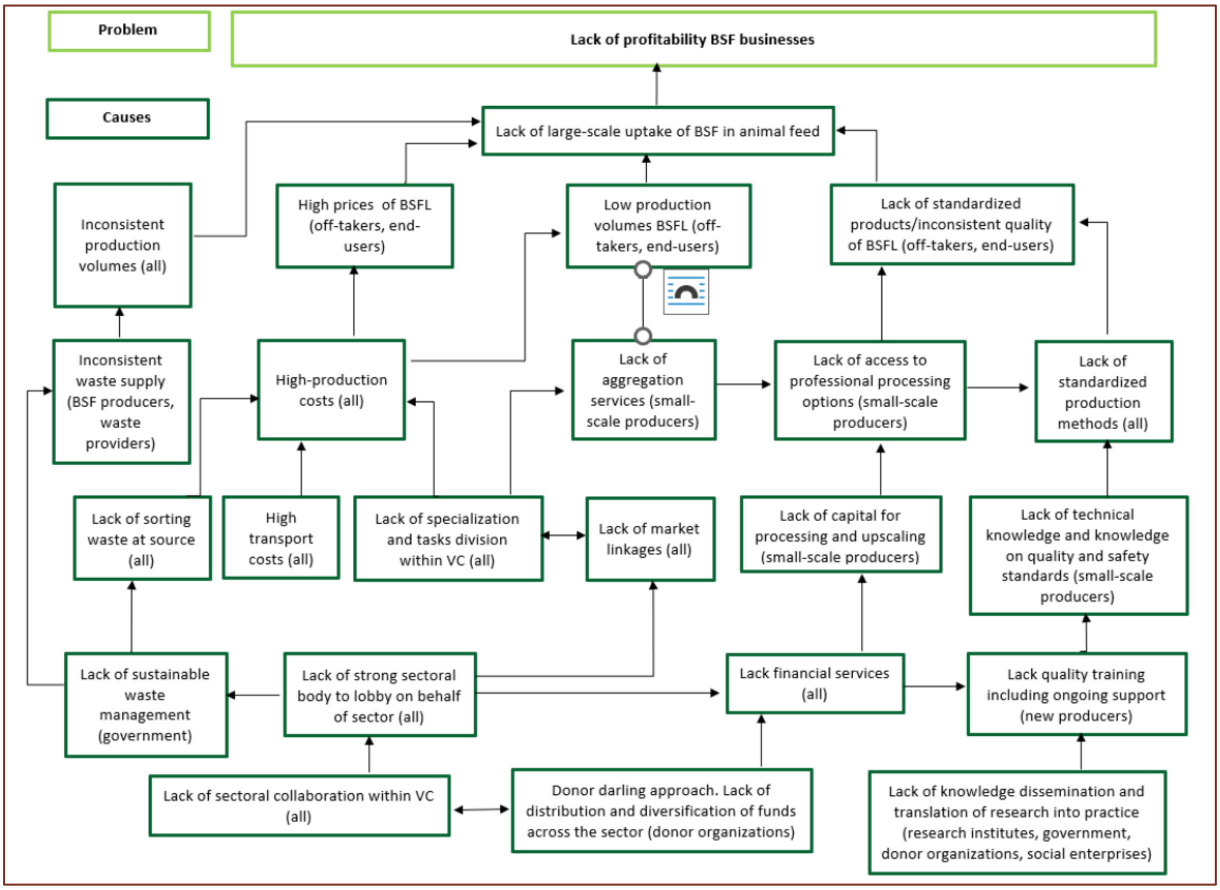
- **Product safety:** Product safety research should focus on post-harvest pest and contamination control, the quality and contamination risks of solar-dried larvae, shelf-life extension to prevent spoilage, microtoxin development in stored larvae and transfer risks in animal feed, and the impact of waste contamination on end-products.
- **Product development:** Product development research should explore BSF oil applications, investigate de-fatted BSF product characteristics (including shelf life and animal growth performance), standardize optimal BSF-based feed recipes for diverse animals, and identify other potential BSF-derived products.
- **Processing:** Processing research should focus on standardizing and optimizing BSFL drying for consistent quality, exploring quality grading systems for dried BSF, and identifying less capital-intensive alternative processing methods. Climate change research needs more extensive and long-term studies on GHG related to BSF production and the impact of climate change on optimal BSF production locations.
- **Frass usage:** Frass fertilizer research should investigate its effects on beneficial soil organisms, determine optimal soil inclusion levels for improved quality, and explore the benefits of combining frass with other inputs, identifying suitable combinations for different crops.
- **Waste feedstock:** Waste research should explore alternative substrates for BSF rearing, particularly focusing on methods like fermentation to enhance waste quality for improved larvae growth and investigate the utilization of highly nutrient-dense waste streams.
- **Breeding program:** Breeding programs should focus on optimizing and selectively breeding BSF for traits like rapid growth, larger size, increased female ratio, more aggressive males, efficient mating, and higher egg fertility. Research into the chemical ecology of BSF is needed to identify attractants that can encourage females to lay eggs.
- **Policy development:** Policy development requires further research to create enabling and inclusive policies that support the growth of the BSF sector, including policies at a continental level and those related to waste management.
- **Business Development:** BSF business development research should investigate effective strategies for scaling BSF businesses and establishing robust market linkages, including connections to financial services. It should also identify barriers and opportunities for BSF farmers to attract investment for scaling their operations. Consumer appeal should be addressed through research on effective packaging and labelling of BSF products. Furthermore, the integration of artificial intelligence in rearing conditions and production systems, focusing on monitoring, data integration, and technological advancements, warrants significant research attention.[13]

[13] FAO (2023). Mapping of the Black Soldier Fly value chain in East Africa.

1.6 Problem tree BSF value chain

Figure 1-3 shows a problem tree for the BSF value chain which was developed for Kenya by the FAO.[14] The results of this work, regardless of the more developed BSF value chain in Kenya compared to the target countries of this guide (Uganda, Ethiopia and Cote d'Ivoire) is providing a good overview about the barriers for the development of a profitable BSF value chain in African countries and the interrelationships between the identified obstacles to develop the local BSF sector.

Figure 1-3: Problem tree BSF value chain



Source: FAO (2023). Mapping of the Black Soldier Fly value chain in East Africa.

1.7 BSF as a powerful climate mitigation tool

1.7.1 GHG emissions of the BSF insect technology in comparison to composting

The reduction of methane has been put on high on the agenda in the last years because among climate scientists it is agreed that to reach the Paris Agreement climate goals a focus on short living climate gases has to be done. Methane is of special interest because of its high warming potential and the fact that it has been neglected in many climate discussions by policy makers. With a Global Warming Potential (GWP) 80 times higher than CO_2 if seen over a time period of

[14] FAO (2023). Mapping of the Black Soldier Fly value chain in East Africa.

20 years, it is a huge environmental challenge. Around 20 % of global methane emissions are coming from the not proper organic waste management.[15] In industrialized countries like the EU, organic waste landfilling is largely banned and treated to avoid methane emissions. Conversely, in developing nations, organic waste treatment is minimal, though some are now considering landfill bans. Notably, the informal sector rarely addresses this waste. The higher organic fraction in these countries makes the problem urgent. Increased interest in organic waste treatment stems from methane reduction being vital for NDC obligations under the Paris Agreement.

The most common technology to treat organic waste is still composting. The lack of subsidies in many developing countries lead to low-tech composting facilities, in order to allow a profitable project. Poorly designed projects with unsuitable technology often lead to inadequate biodegradation in compost piles. This can create anaerobic conditions and corresponding methane emissions. While these projects are better than untreated landfilling, they fail to fully leverage the methane emission reduction potential of proper organic waste treatment.

The BSF insect technology has the advantage that it allows to see organic waste rather as a resource than a waste because the produced final product is a high value-added protein product with a high demand worldwide. This allows to implement profitable projects in developing nations with the selection of suitable technological equipment.

Studies about the GHG reduction potential of the BSF insect technology are rare, but first scientific projects to measure its potential regarding methane emission reduction are very promising. The most comprehensive investigation in this regard was undertaken by Mertenat et. al.[16] which did compare the BSF insect technology with the traditional composting process regarding its GHG emissions. The result is shown in Figure 1-4 and clearly shows that during the organic waste treatment process the emissions from BSF projects are less than half of the emissions which result by composting. This analysis was undertaken for an BSF insect plant in Indonesia and is of course very site specific.

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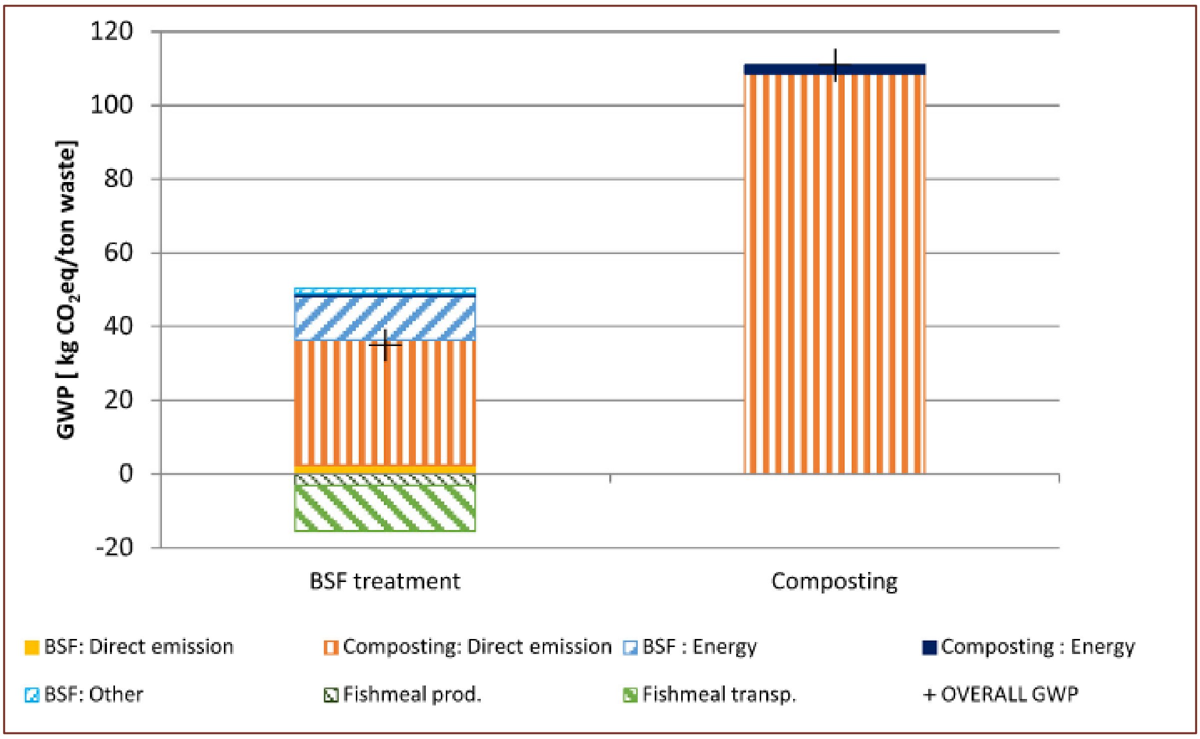
[15] UNEP (2021). Global Methane Assessment – Summary for decision makers.

[16] Mertenat, A., Diener, S. & Zurbrügg C. (2019). Black Soldier Fly biowaste treatment – Assessment of global warming potential.

Figure 1-4 Comparison of GHG emission between BSF insect technology and traditional composting



Source: Mertenat, A., Diener, S. & Zurbrügg C. (2019). Black Soldier Fly biowaste treatment – Assessment of global warming potential.

The reason for this good result for the BSF insect technology lays in the fact that larvae are constantly in movement and therefore mixing the substrate what allows that the aeration of the substate is ideal. No anaerobic conditions can evolve and therefore during the biodegradation process no methane emission can occur. In composting plants, regardless of the used technology, always small amounts of methane are produced, and this deteriorates the GHG mitigation result significantly.

Figure 1-4 also shows, that additional to the reduction of methane, additional climate mitigation effects have to be considered if the BSF technology is used. This GHG reductions are coming from the replacement of unsustainable fish meal by avoiding emissions during transport and production of the fish meal.

1.7.2 Factors influencing GHG emissions of BSF insect plants

Despite its good performance to reduce GHG emissions during the treatment process, several factors have to be considered to assess the GHG mitigation potential of BSF insect plants. Some of these factors actively can be controlled, that allows the optimization of the GHG mitigation potential of the technology.

The most relevant influence factors are:

- **Climate conditions:** The BSF is adapted to tropical climate conditions with average temperatures between 25-27 degree Celsius and high humidity. If BSF projects are implemented in climate zones, where these conditions cannot be met naturally, the BSF plants have to use HVAC technology for the climatization of the breeding and rearing parts of the plant. Depending on the climate conditions and its seasonal variations different climatization needs have to be considered in the plant design.

- **Type of energy supply:** The cited study above about the GHG reduction of the BSF technology in Indonesia is based on an electricity supply from the Indonesian electricity grid, which is with a share of >70% of fossil fuels, so a rather dirty electricity grid. BSF insect projects which are connected to cleaner electricity grids, or are producing their own energy with renewable energies, can reduce the CO_2 footprint of this technology even more. Interesting are also BSF projects which use part of the organic waste, the excess water from the substrate preparation step, and the frass (organic fertilizer) as input for a biogas plant in order to produce electricity and heat for the BSF insect plant. Such integrated solutions are highly sustainable and have a very low carbon footprint and are maximizing the GHG mitigation of such facilities.
- **Cleanliness of organic waste and pre-processing requirements:** The pre-processing of the organic substrate is another energy demanding process step. Depending on the cleanliness of the available raw organic waste and the physical characteristics of the organic waste, different electricity consuming machineries have to be used in order to transform the organic waste into a suitable substrate to feed the larvae. Because organic waste streams are very heterogenous, each plant has a different energy use profile.

1.7.3 GHG emission reduction potential of the BSF solution under the African context

For the estimation of the mitigation potential of the BSF technology a landfill gas estimation was done, in order to estimate how much GHG would be produced in the base case, where all the biowaste is landfilled or dumped in dumpsites, as it is currently the practise in most countries in Africa. For this purpose, the Tabasaran-Rettenberger approach was used, which is an easy to use and reliable formula for the calculation of landfill gas. In this approach the landfill gas quantity is proportional to the biogenic degradable carbon inside the waste. This formula gives you the total quantity irrespective of the time frame.

Tabasaran-Rettenberger Formula:

$$G_e = 1{,}868 * C_{org}$$

G_e = Total landfill gas quantity in t/m^3 waste

C_{org} = biologically degradable organic carbon content in kg C/t waste

This estimation also assumes that all biogenic degradable carbon is transformed to methane due to anaerobic conditions. Which might not be totally correct as there is some aerobic degradation going on at the landfill before the waste is buried and the conditions get anaerobic. So, the quantity of C(organic) that is contributing to methane formation gets reduced maybe by 10 – 20 % depending on how quick the waste is buried and how the weather conditions are.

The first question is how much C (organic) is there in the biowaste to be landfilled.

For biowaste we can assume 180 g/kg = 180 kg/t of organic carbon.[17] If we take that as an input into the Tabasaran-Rettenberger formula, we get a total of 336.24 m³ of landfill gas per tonne of that biowaste. As more than 95% is transformed within 30 years it can be concluded that this is the amount which can used for a holistic assessment of the climate relevance of diverting the biowaste from the landfilling or dumping into dumpsites.

Based on 336.24 m³ landfill gas per tonne of biowaste we will have around 168.12 m³ of methane and 168.12 m³ of carbon dioxide assuming a 50% concentration of methane and carbon dioxide respectively as well as thermodynamical standard conditions. If we assume a volume of 1 m³ gas at standard conditions and the molar masses of methane and carbon dioxide respectively we result in 120.1 kg of methane and 330.2 kg of carbon dioxide per tonne of biowaste.

As the emitted CO_2 is part of the natural biodegradation process and would have been produced anyhow, in the case the residues would not have been landfilled, they can be neglected in this calculation. Just the methane as consequence of the anaerobic conditions in the landfill are additional GHG emissions as consequence of landfilling.

The here discussed potential methane reduction potential estimation is based on a couple of assumptions, which have to be verified if a real project is implemented:

- The BSF plant is 100% operated by renewable energy.
- How long does it take until the organic waste is buried at the landfill? If the time is longer, more organic carbon is degraded under aerobic conditions, without producing methane emissions.
- Temperature and humidity at the landfill side.
- The raw organic waste has an organic carbon content of 180 g/kg. This can vary between different types of organic waste streams and should be verified for a concrete project by laboratory analysis.
- In the organic waste are 10-20% of inert impurities. (Estimation based on 20%).

So far just the GHG mitigation potential of the organic waste treatment aspect has been considered in this estimation. But if we want to do a holistic assessment, we also have to account for what we avoid on the side of the protein that we are able to substitute (fish feed, fossil fertilizer replacement, transport, avoided deforestation, etc.)

To get to a complete picture about the GHG performance of the BSF technology we would have to include into the assessment of course also all these avoided emissions as a consequence of replacing unsustainable fish feed by a sustainable alternative. Such assessment would depend on different scenarios, for example if we compare BSF insect protein with fish meal, soy production or with cattle farming. In the case of soy and cattle farming the deforestation aspect as well as the GHG emissions from using fossil fertilizers would have to be included in the estimation. Such holistic carbon foot printing would go

[17] Rolland, C., Scheibengraf, M. (2003). Biologisch abbaubarer Kohlenstoff im Restmüll.

beyond the scope of this project; therefore it should just be mentioned that additional GHGs are avoided, which improves even more the GHG mitigation potential of the BSF technology.

1.7.4 Roll-out scenario for diverting the organic waste from dumping

This chapter outlines a strategic roll-out scenario to demonstrate the significant potential of the BSF technology for organic waste treatment if the BSF solution in the target countries of this projects would be rolled out on a larger scale. It illustrates the substantial environmental benefits in terms of GHG emission reductions achievable by, for instance, diverting a percentage of 10% of organic waste from current dumping practices in each target country. The emission factors which are used for these scenarios have been calculated in chapter 1.7.3 resulting in 120.1 kg of methane per tonne of biowaste without proper treatment *[**Note**: Methane emissions from landfilled organic waste are very situation dependent and can vary significantly]* and by using the data calculated for BSF by Mertenat et al.[18] as shown in

Figure 1-5. For that purpose a GHG footprint for BSF treatment of 50 kg of CO_2e per tonne of treated organic waste is used. Indirect GHG emission reduction by replacing fish meal or soy meal have not been included into this calculation. The main share of the BSF related emissions are generated during the composting phase of the insect frass. This could eventually be avoided or reduced if alternative frass stabilization methods are applied.

If we assume for methane a 28-times higher GWP than for CO_2 over a 100-year period,[19] we can calculate a **GWP of around 3.360kg of CO_2e per tonne of untreated biowaste**.

This means that for one tonne of organic waste the avoided GHG emissions corresponds to 3.360 kg CO_2e (methane from anaerobic conditions from dumped organic waste) minus 50 kg CO_2e (coming from the BSF process) what results in a net **GHG emission reduction of around 3.31 tonnes CO_2e per tonne of treated organic waste**.

To show the impact which a scaling up of the BSF solution would have for the target countries, for each country a scenario has been developed in which it is assumed that 10% of all organic waste is treated with the BSF solution in each country. The results are shown in Figure 1-5.

Figure 1-5: Scenarios to show the impact of BSF treatment if 10% of organic waste would be treated per country with the BSF solution

Country	Total organic waste/year	Total GHG emissions from untreated organic waste	10% of organic waste	Emission reduction per year if 10% are treated with the BSF solution
Ethiopia	39 Mt	131.04 Mt	3.9 Mt	**12.91 Mt**
Cote d'Ivoire	9.6 Mt	32.26 Mt	0.96 Mt	**3.18 Mt**
Uganda	15 Mt	50.40 Mt	1.5 Mt	**4.97 Mt**

Source: Own elaboration by the author of this publication (in millions of tonnes per year)

[18] Mertenat, A., Diener, S. & Zurbrügg C. (2019). Black Soldier Fly biowaste treatment – Assessment of global warming potential.

[19] https://www.ccacoalition.org/short-lived-climate-pollutants/methane

Assumptions for scenarios:

- *Organic waste fraction in MSW 50% (in practise most likely higher, data not available).*
- *10% of the organic waste in a roll-out scenario per country would be treated with the BSF solution.*
- *The 10% treated by the BSF are currently landfilled and not used or treated in an alternative way.*
- *MSW per capita/day of 0.6 kg.*
- *Population: Uganda 50 millions, Ethiopia 130 millions, Cote d'Ivoire 32 millions.*

Of course, to reach a treatment of 10% of all organic waste with the BSF solution would require a massive scaling-up of the solution. Not all organic waste is suitable for BSF and separation at source on a larger scale would be a requirement in order to source enough organic waste for this scenario. Nevertheless, this threshold seems to be realistic under the beforehand mentioned assumptions.

1.7.5 Emphasising the significance of reducing Short-Lived Climate Pollutants (SLCPs) like methane

The global climate crisis demands urgent and multifaceted action. While long-term strategies rightly focus on reducing CO_2 emissions, an equally critical component of effective climate mitigation involves tackling Short-Lived Climate Pollutants (SLCPs). These powerful climate-forcing agents, which include methane (CH_4), black carbon, tropospheric ozone, and hydrofluorocarbons (HFCs), have relatively short atmospheric lifespans compared to CO_2, but possess a significantly higher global warming potential (GWP).[20] Addressing SLCPs offers a unique opportunity for rapid and substantial climate benefits, complementing efforts to decarbonize the global economy.

The importance of reducing methane emissions to reach short- and medium-term climate mitigation goals is paramount. Methane, in particular, is a potent greenhouse gas with a global warming potential approximately 28 to 34 times greater than CO_2 over a 100-year period, and even higher (around 80 times) over a 20-year period.[21] Unlike CO_2, which can persist in the atmosphere for centuries, methane has a much shorter atmospheric lifetime, typically around 12 years.[22] This relatively short lifespan means that reducing methane emissions yields almost immediate and tangible climate benefits. Aggressive methane mitigation can significantly slow the rate of near-term warming, effectively "buying time" for the implementation of more extensive, long-term decarbonization strategies.[23]

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[20] CCAC (2024). Short-Lived Climate Pollutants - Pollutants with strong warming potential and significant impacts on health and the environment. Link: https://www.ccacoalition.org/content/short-lived-climate-pollutants

[21] IPCC (2021). Climate Change 2021- The Physical Science Basis. Link: https://digitallibrary.un.org/record/3934600?v=pdf

[22] IPCC (2021). Climate Change 2021- The Physical Science Basis. Link: https://digitallibrary.un.org/record/3934600?v=pdf

[23] Shindell, D. et al. (2012). Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security; Link: https://pubmed.ncbi.nlm.nih.gov/22246768/

For African nations, where organic waste decomposition in landfills and open dumps is a major source of methane emissions, prioritizing methane reduction offers a dual advantage. Firstly, it directly contributes to national climate mitigation targets and enhances the ambition of NDCs by addressing a high-impact pollutant. Secondly, and crucially, it delivers rapid improvements in local air quality and public health by reducing associated pollutants.[24] By focusing on immediate methane reductions through solutions like BSF bioconversion of organic waste, countries can demonstrate leadership in climate action, achieve visible environmental benefits in the short to medium term, and build momentum for broader sustainable development goals. This strategic focus on SLCPs, especially methane, is a powerful lever for accelerating climate progress and fostering a more resilient future.

1.7.6 Embedding BSF into national NDC to contribute to comply with national and global climate change mitigation goals

NDCs represent the foundational commitments of each country under the Paris Agreement, outlining their pledges to reduce greenhouse gas (GHG) emissions and enhance climate resilience. These national targets are critical for achieving the global objective of limiting average temperature increase to well below 2 degrees Celsius, ideally to 1.5 degrees Celsius, above pre-industrial levels. For many African nations, NDCs signify a resolute commitment to transitioning towards lower-carbon development pathways, necessitating the identification and implementation of effective and scalable mitigation strategies across all relevant sectors.

Positioning sustainable organic waste management, particularly through the adoption of the BSF solution, as an explicit and central strategy within NDCs is critical for several compelling reasons directly linked to climate change mitigation and climate adaptation. The waste sector, specifically the decomposition of organic waste in landfills and dumps, constitutes a significant and often underestimated source of potent greenhouse gases, notably methane. Methane is a powerful short-lived climate pollutant, capable of trapping substantially more heat in the atmosphere over a shorter timeframe compared to CO_2. Therefore, effective methane mitigation from organic waste is not just a beneficial environmental action but also a strategic imperative for countries aiming to achieve ambitious climate targets.[25]

Incorporating BSF solutions into NDC strategies offers a direct and highly efficient mechanism for reducing these climate-forcing emissions. BSF technology precisely targets the organic fraction of waste, which is the primary source of landfill methane emissions. By rapidly bioconverting this organic material under aerobic conditions, BSF systems prevent the anaerobic decomposition that leads to methane generation. This direct intervention provides a quantifiable pathway for significant greenhouse gas emission reductions.[26] Explicitly

[24] WHO (2025). Air pollution.
[25] IPCC (2021). Climate Change 2021- The Physical Science Basis.; UNEP & CCAC (2022). Global methane assessment: 2030 Baseline Report.
[26] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

embedding BSF-based waste management targets within NDCs allows countries to translate broad climate ambitions into concrete, implementable actions that yield measurable results. It provides a robust framework for tracking progress, reporting emission reductions, and demonstrating a proactive approach to fulfilling national and global climate commitments.[27]

Strategic inclusion of BSF as a key mitigation measure within NDCs enhances a nation's climate pledges. As an innovative, nature-based solution, it is particularly well-suited to African contexts with high organic waste and limited traditional infrastructure. Leveraging BSF capabilities accelerates progress towards near-term climate goals by rapidly mitigating high-impact methane, complementing long-term decarbonization efforts. Ultimately, integrating BSF into NDCs ensures more comprehensive and effective climate action, delivering significant contributions to national and global mitigation objectives.[28]

1.8 BSF as powerful opportunity for gender equality and youth participation

The expanding BSF sector in Africa presents broad opportunities to advance gender equality and youth empowerment, fostering economic resilience and inclusive participation in the circular economy by directly addressing critical socio-economic challenges. By strategically developing the BSF value chain with intentional inclusion, this technology empowers women and youth, fostering sustainable livelihoods, and driving inclusive economic development, beyond just environmental benefits.

For women, BSF farming offers pathways to entrepreneurship and financial independence; its flexible nature allows income generation integrated with household responsibilities, directly contributing to family welfare. Women gain valuable skills in sustainable agriculture, waste management, and business, enhancing community waste efforts, securing livestock protein, fostering food security, and taking on leadership roles.

Youth benefit immensely from BSF growth, directly addressing widespread unemployment. As a nascent, tech-forward field, it appeals to a generation keen on modern practices, providing numerous entrepreneurship opportunities in farming, processing, or distribution. Participation facilitates highly relevant skills acquisition for green economy jobs, serving as an attractive alternative to traditional farming, promoting rural economic revitalization and reducing urban migration.[29]

[27] UNFCCC (2025). Nationally Determined Contributions (NDCs) - The Paris Agreement and NDCs.
[28] CCAC (2025). Supporting Argentina from NDC to Action - Methane Reductions through Organic Waste Diversion & Use.
[29] UNCDF (2023). Empowering Women and Youth in Uganda's Kalangala Islands Through Black Soldier Fly Farming.

BSF implementation roadmap

2 Step-by-Step BSF implementation roadmap for policymakers

2.1 Phase 1: Feasibility & Stakeholder Engagement

2.1.1 Waste audits & waste characterization:

Effective implementation of the BSF technology in African contexts begins with a precise understanding of the available organic feedstock. This initial phase involves comprehensive waste audits and detailed characterization studies, which are crucial for accurately sizing BSF operations and optimising rearing protocols.

[***Note***: *Please refer also to the specific documents elaborated for the feasibility assessment and guidelines in Uganda, Cote d'Ivoire and Ethiopia as part of this BUGS project.*][30]

Mapping Organic Waste Sources and Quantifying Volumes

The primary objective is to systematically map all potential organic waste sources within a defined spatial region. A precise spatial scope enhances the accuracy of the assessment. In many African urban and peri-urban environments, organic waste streams are diverse and often localized, typically originating from:

- **Agro-industries:** Including food processing (e.g., bakeries, canning), beverage production (e.g., brewery waste, coffee grounds), meat and fish processing (e.g., slaughterhouse offal, blood), and sugar or vegetable oil production by-products (e.g., bagasse, oilseed cake).
- **Food wholesale and retail:** Notably from open-air markets, informal vendors, and supermarkets, which generate substantial quantities of spoilt food items and fruit and vegetable discards.
- **Hotel, Restaurant, and Catering:** A consistent source of mixed kitchen and food waste.
- **Households:** contributing the largest fraction of municipal solid waste, often with a high organic content that may be mixed due to limited source segregation.
- **Agricultural production:** Including spoilt crops, various crop residues, animal manure, and aquaculture sludge from fish farms.
- **Sanitation systems:** Such as fecal sludge from latrines and septic tanks, and biosolids from wastewater treatment facilities.

Quantifying the volumes generated from these sources is essential for determining the potential scale of a BSF facility. Methodologies often combine primary data collection, such as direct weighing at source or collection points, with analysis of existing municipal waste reports or industry records. Given the scarcity of reliable secondary data in many African

[30] PREVENT Waste Alliance (2024). BUGS Project: Biomass Utilization by Insects for Green Solutions in Africa through Black Soldier Fly Technology.

settings, robust primary data collection campaigns are particularly important. Assessing seasonal reliability is also crucial, especially for agro-industrial or agricultural waste, to ensure a consistent feedstock supply throughout the year.

Characterising Waste Types and Composition

Beyond volume, a detailed characterisation of the waste types and their intrinsic properties is imperative for BSF applications.

This involves:

- **Physical composition analysis:** Identifying the proportion of organic matter versus inorganic contaminants (e.g., plastics, metals, glass). The prevalence of mixed waste streams in many African urban areas often means higher levels of inorganic contamination, impacting the need for pre-sorting.
- **Nutritional composition analysis:** This is critical for optimizing BSF larvae growth and ensuring the quality of the resulting larval meal and frass. BSF larvae generally thrive on substrates rich in digestible protein (typically >10% dry mass), non-fibrous carbohydrates (20-30% dry mass), and fat (10-15% dry mass), while being low in indigestible fibres and ash. Laboratory techniques like proximate analysis are commonly employed for this assessment.
- **Moisture content assessment:** BSF larvae optimally convert organic matter at substrate moisture levels typically ranging from 60-75%. Understanding this ensures that the waste is suitable or that pre-treatment (e.g., dewatering or dilution) is planned.

Assessing Suitability for BSF Farming

The comprehensive data gathered from waste audits and characterization informs the assessment of a waste stream's suitability for BSF bioconversion, considering operational aspects and economic viability.

- **Processing suitability:** Key factors include the nutritional adequacy of the waste to support robust larval growth, its moisture content, and crucially, its safety. This involves stringent assessment for the absence of hazardous contaminants such as mycotoxins, veterinary drugs, agro-chemicals, pathogens, or heavy metals. Adherence to national regulations, which may restrict certain substrates, serves as a primary exclusion criterion. Waste purity (i.e., low inorganic contamination) is also vital for ensuring smooth processing and minimizing operational issues.
- **Procurement viability:** This evaluates the economic and logistical aspects of acquiring the waste. Considerations include the price of the waste (whether it can be sourced free of charge, at low cost, or if a positive gate fee can be secured), the ease and cost of procurement (logistics, transportation from often dispersed sources, considering road infrastructure in various regions), and any existing competition for demand from other informal or formal waste handlers.

This foundational phase of waste auditing and characterization, tailored to the specificities of African waste streams and collection landscapes, provides essential data for informed decisions in BSF project design.

2.1.2 Socio-economic context analysis

This socio-economic context analysis aims to understand the local economic landscape, prevalent agricultural practices, the potential for market adoption of BSF products, and appropriate strategies for community engagement.

Understanding local economic conditions and existing agricultural practices

Understanding the prevailing local economic conditions is foundational for BSF project planning. This involves examining the structure of the economy, including the balance between formal and informal sectors, income levels, and the overall business environment. Indices such as the "Ease of Doing Business Index"[31] which evaluates aspects like starting a business, access to credit, and regulatory frameworks, provide valuable insights into the conduciveness of the regulatory and institutional environment for new ventures, including BSF enterprises. Challenges identified in these areas, such as complex registration processes or limited access to finance, can significantly influence the viability of BSF operations.

Simultaneously, a detailed understanding of existing agricultural practices in the target region is crucial. This includes identifying the dominant farming sectors (e.g., poultry, aquaculture, pig farming, crop cultivation) and their current reliance on specific feed and fertilizer inputs. The scale of these agricultural activities, from smallholder farms to commercial operations, directly determines the potential customer base for BSF products.

Market uptake potential and price competitiveness of BSF products

Assessing the potential for market uptake of BSF products requires an evaluation of both demand volume and consumer acceptance within these identified agricultural sectors.

BSF farming yields several valuable products, primarily:

- **BSF larvae-based animal feed products:** Live/fresh or dried larvae, and refined products (defatted protein meal, fat) are feed components for poultry, pigs, fish, and pets.
- **BSF frass:** Organic bioconversion residue is primarily used as soil conditioner/fertilizer, also for biogas, biochar, or fuel briquettes. Market volume evaluation assesses customer bases in poultry, aquaculture, and crop farming by quantifying conventional input consumption.

A critical component of this analysis is the assessment of the price competitiveness of BSF products against their traditional alternatives.

This is highly specific to the local context and depends on a multitude of factors, including:

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[31] World Bank Group (2025). Ease of Doing Business rankings.

- **For BSF animal feed:** BSF meal's competitiveness against conventional proteins (imported fishmeal, soy meal, corn) improves when their fluctuating costs (due to international markets, freight, local supply) are high or scarce.
- **For BSF frass:** Frass prices compare with local synthetic chemical fertilizers and organic soil amendments. Its value extends beyond nutrient content to soil health/structure, potentially commanding a premium or facilitating market acceptance.

Novel BSF products require understanding customer perception and willingness to switch from conventional options. Assessing farmers' current practices, their openness to innovation, and perceived product quality, efficacy, and safety is crucial. Interviews with local farmers, feed producers, retailers, and agricultural stakeholders are essential to gauge acceptance and identify adoption barriers or facilitators.

Community engagement strategies

Effective community engagement is vital for socio-economic feasibility. This involves identifying key local stakeholders (farmer cooperatives, community leaders, informal waste collectors) and actively involving them in project design and implementation. Understanding local social dynamics, BSF employment opportunities, and ensuring fair practices are crucial for fostering community acceptance and long-term project viability. Engagement strategies should aim to build trust, share knowledge, and address potential concerns regarding waste handling or product use.

2.1.3 Climate condition considerations

The assessment of local climatic conditions is a critical factor in the feasibility and design of BSF rearing facilities. Optimal environmental parameters directly influence the BSF lifecycle, growth rates, and overall bioconversion efficiency, subsequently impacting operational costs and profitability.

Optimal climatic conditions for BSF rearing

BSF facilities are optimally suited for climates with average monthly ambient temperatures typically ranging between 25-30°C and average relative humidity between 60-90%. Within these specific climatic windows, all stages of the BSF lifecycle – from egg incubation to larval growth and adult soldier fly activity – can thrive with minimal need for external environmental manipulation.

Africa's climatic advantage

Many African regions, characterized by tropical/subtropical climates, offer highly favorable conditions for BSF farming. Consistent warm temperatures and adequate humidity significantly reduce the need for expensive, energy-intensive climate control systems. This natural suitability lowers initial CAPEX and ongoing OPEX, directly enhancing the financial feasibility and profitability of BSF waste processing projects across the continent.

Evaluating local conditions and identifying adaptation strategies

Despite general climatic advantage, precise evaluation of specific local temperature, humidity, and other environmental factors (such as ventilation or light cycles) is still essential. This involves assessing average monthly ambient levels and noting any significant seasonal or regional variations.

Where local conditions occasionally deviate from the ideal range, suitable adaptation strategies may be required, albeit with careful consideration of their cost implications:

- **Passive Measures:** For minor deviations, passive controls such as strategic building orientation, natural ventilation, shading, or basic spray humidifiers might suffice to maintain favourable internal conditions. These typically involve lower investment and operational costs.
- **Active Measures:** In more challenging microclimates where temperatures consistently fall below 20°C or rise above 35°C, or where humidity levels are below 40% or above 90%, more active climate control systems (e.g., powered heating, cooling, or dehumidification) may be necessary. While BSF processing can be conducted in fully closed facilities with comprehensive environmental control, the financial viability of such systems can become more challenging due to increased energy consumption and associated operational costs.

Therefore, a thorough climate condition assessment helps identify regions where BSF operations can benefit most from natural conditions, thereby minimizing the need for costly infrastructure and maximizing the economic viability of sustainable organic waste management in Africa.[32]

2.1.4 Stakeholder mapping and engagement

The successful and sustainable implementation of BSF solutions in Africa is fundamentally contingent upon robust and inclusive stakeholder engagement. This critical phase involves systematically identifying all key actors, understanding their respective roles and interests, and developing effective strategies for their active involvement and collaboration throughout the project lifecycle. A fragmented approach to BSF development risks encountering social resistance, operational misalignments, and limited uptake.

Identifying key actors and their relevance for engagement

A comprehensive stakeholder mapping exercise is the foundational step, ensuring that all relevant parties are recognized and their potential contributions or influences on a BSF initiative are understood from an engagement perspective. In the African context, key actors typically span multiple sectors and levels:

Government agencies

[32] Salam, M. et al. (2022). Effect of different environmental conditions on the growth and development of Black Soldier Fly Larvae and its utilization in solid waste management and pollution mitigation.

These entities are important for facilitating an enabling environment and ensuring regulatory alignment. Relevant bodies for engagement include:

- **National ministries:** Such as the Ministry of Agriculture, Animal Industry and Fisheries Ministry of Water and Environment, Ministry of Health, Ministry of Trade, Industries and Cooperatives, Ministry of Finance, Planning and Economic Development, and Ministries responsible for Science, Technology & Innovation. Engagement with these ministries is crucial for advocating for supportive frameworks and integrating BSF into broader national strategies.
- **Regulatory bodies:** Entities like National Bureau of Standards (e.g., Uganda National Bureau of Standards - UNBS), National Drug Authorities, and environmental protection agencies. Their engagement is vital for establishing and adhering to product safety, quality control, and environmental compliance standards for BSF operations.
- **Local governments and municipal authorities:** Such as city authorities and district local government authorities. These are crucial partners as waste management is often decentralized, making their buy-in essential for waste collection, transport, and local by-laws impacting BSF facilities.

Non-Governmental Organizations (NGOs) and Community-Based Organizations (CBOs)

These organizations often possess deep connections within local communities and can facilitate grassroots engagement, awareness campaigns, and community-led pilot projects. Their expertise in areas like community development, sustainable agriculture, and waste management makes them valuable allies for outreach and localized problem-solving.

Private sector entities

Their involvement is critical for scaling BSF solutions and driving commercial viability. This diverse group includes:

- **Investors and financial institutions:** Engaged for capital mobilization and sustainable financing mechanisms.
- **Project developers and entrepreneurs:** Those directly involved in establishing and operating BSF farms.
- **Existing waste management companies:** Potential partners for integrating BSF into existing waste collection and processing services.
- **Agribusinesses:** Such as large-scale poultry farms, aquaculture operations, and animal feed manufacturers, who represent key potential off-takers for BSF products.
- **Agricultural input suppliers:** Who could serve as distribution channels for BSF frass.

Communities and end-users

These groups are fundamental, as they are both sources of organic feedstock and potential consumers of BSF products. This category includes:

- **Households and market vendors**: As primary generators of organic waste.

- **Informal waste pickers:** A significant part of the waste management ecosystem in many African cities, whose integration into formal BSF value chains needs careful consideration to ensure equitable participation.
- **Local farmers:** Both smallholder and commercial, who are the ultimate end-users of BSF feed and frass products.
- **Community leaders and associations:** Whose support and endorsement can significantly influence local acceptance and participation.
- **Academia and research institutions:** Universities and research centers provide scientific validation, technical expertise, and play a role in capacity building and continuous innovation tailored to local conditions.

Developing strategies for stakeholder involvement and collaboration

Effective stakeholder engagement extends beyond mere identification; it involves fostering genuine participation and co-ownership. Strategies should be tailored to the specific interests and capacities of each group, particularly within the diverse socio-cultural landscapes of Africa:

- **Multi-Stakeholder workshops and dialogue platforms:** Convening multi-stakeholder workshops (municipalities, NGOs, agribusinesses, community groups) effectively co-designs BSF frameworks. These platforms facilitate shared understanding, collaborative problem-solving, and building consensus on regulatory needs, market development, and community integration. Such workshops lead to localized, widely supported BSF roadmaps or policy recommendations.
- **Capacity building and knowledge transfer:** Providing targeted training and technical assistance to government officials, entrepreneurs, and community groups builds local expertise and confidence in BSF rearing, processing, and product application.
- **Pilot projects and demonstration sites:** Establishing visible and successful pilot BSF projects serves as powerful demonstration sites, showcasing the technology's viability and benefits firsthand, thereby building trust and encouraging wider adoption. These pilots should actively involve local communities and businesses.
- **Policy dialogue and advocacy:** Engaging directly with relevant ministries and regulatory bodies facilitates the development of supportive policies, clear regulations, and incentives that de-risk BSF investments and streamline market access for BSF products. This direct engagement fosters an enabling environment for BSF sector growth.
- **Inclusive participation:** Designing BSF initiatives with inclusive business models that actively integrate informal waste pickers, smallholder farmers, and local communities ensures equitable benefit sharing and enhances social acceptance. This may involve formalizing their roles or establishing community-owned BSF units.
- **Targeted communication and awareness campaigns:** Developing culturally sensitive communication strategies to inform the public about the benefits of BSF, address any potential misconceptions, and promote the acceptance of BSF-derived products.

By strategically mapping and actively engaging this diverse range of stakeholders, BSF initiatives can harness collective expertise, build necessary alliances, and navigate complex local dynamics, laying a robust foundation for sustainable and impactful organic waste management solutions across Africa.

2.1.5 Policy diagnostics

Before new BSF policies or large-scale initiatives, a thorough policy diagnostic is essential. This involves reviewing existing national/sub-national waste management strategies, climate plans (NDCs), agricultural policies, and economic frameworks. The aim is to understand organic waste's priority, BSF's regulatory fit, and integration opportunities/barriers. This diagnostic identifies key entry points, leverages political will, and ensures aligned, effective policy recommendations.

2.1.6 Feasibility studies

[**Note**: Please refer also to the specific documents elaborated for the feasibility assessment in Uganda, Cote d'Ivoire and Ethiopia as part of this BUGS project.][33]

Comprehensive feasibility studies are a critical step in BSF implementation. They systematically evaluate project viability via tailored economic, social, and environmental assessments, ensuring initiatives are technically sound, economically sustainable, and socially acceptable. Assessments analyse costs/revenues, BSF market dynamics, socio-economic impacts (employment, resource access), and environmental effects (waste reduction, GHG emissions, ecological footprints), aligning with sustainability objectives.

For in-depth guidance and examples of such assessments, policymakers and project developers are encouraged to refer to the feasibility assessments already conducted as part of the comprehensive feasibility guidelines developed by the this project for Uganda, Ethiopia and Cote d'Ivoire, which is providing detailed methodologies and tools for undertaking rapid feasibility assessments, offering practical frameworks for evaluating opportunities and challenges for waste-based BSF farming across various scales and business model. These existing resources offer invaluable insights and templates for conducting robust and localized feasibility analyses and can be downloaded from the PREVENT webpage.[34]

[33] PREVENT Waste Alliance (2024). BUGS Project: Biomass Utilization by Insects for Green Solutions in Africa through Black Soldier Fly Technology.
[34] PREVENT BUGS Project

2.2 Phase 2: Supporting pilot implementation

2.2.1 Site selection and infrastructure development

The successful transition from feasibility assessment to pilot implementation for BSF operations necessitates a careful approach to site selection and the subsequent development of essential infrastructure. This stage is important for establishing operational efficiency, ensuring sustained feedstock availability, and facilitating effective market access for BSF products.

Identification of priority areas

Priority areas for BSF pilot implementation are identified based on favorable conditions previously assessed. These typically include:

- **High organic waste generation:** Locations with a consistent and substantial volume of suitable organic waste, generally exceeding 5-10 tonnes per day, are prioritized. This is critical for ensuring a stable feedstock supply.
- **Local demand for BSF products:** Areas exhibiting an established or emerging market for BSF-derived products, such as insect protein for animal feed or frass for organic fertilizer, are preferred.
- **Favourable climatic conditions:** Regions that present optimal temperature and humidity ranges for BSF rearing offer a natural advantage, potentially reducing the need for extensive environmental controls.
- **Existing agricultural networks:** Proximity to established feed or farm networks can streamline the distribution of BSF products and foster collaboration with end-users.

Guidance for choosing appropriate locations and setting up BSF rearing facilities

For stakeholders, whether planning small-scale community projects or larger industrial setups, choosing an appropriate location and establishing the necessary infrastructure are key decisions. The following criteria provide a practical checklist to guide project developers in identifying suitable sites:

- **Proximity to organic waste sources:** The chosen site should minimize the distance between primary waste generators and the BSF facility. This directly reduces transportation costs and logistical complexities associated with feedstock procurement, a significant factor in the African context where waste collection logistics can be challenging.
- **Access to essential infrastructure:** Reliable access to vital services is non-negotiable for consistent operation:
- **Electricity:** Required for lighting, ventilation systems, and any automated processing equipment.
- **Water supply:** Necessary for maintaining substrate moisture, cleaning operations, and potentially for BSF colony hydration.
- **Wastewater and effluent management:** Adequate systems must be in place for managing leachate from waste processing and any facility wastewater, ensuring environmental compliance.

- **Road access:** Robust and accessible road networks are essential for efficient transport of both incoming waste and outgoing BSF products, accommodating various vehicle sizes.
- **Access to off-take markets for products:** The site's location should facilitate cost-effective distribution of BSF products (larvae, protein meal, oil, frass) to target customers, such as local farms, feed manufacturers, or fertilizer distributors, thereby enhancing market competitiveness.
- **Land availability and cost:** Sufficient land area is required for BSF rearing units, waste reception, processing, product storage, and potential future expansion, at a commercially viable acquisition or leasing cost.
- **Local zoning and regulatory considerations:** An initial assessment of local land-use zoning regulations and specific permitting requirements for waste processing or industrial operations is crucial to mitigate potential regulatory hurdles during project development and operation.
- **Community acceptance and nuisance mitigation:** Given the nature of organic waste processing, selecting sites with adequate buffer zones and proactive engagement with local communities is important to address and mitigate potential concerns related to odour or pest attraction, thereby ensuring social acceptance and sustained operations.

By systematically evaluating these interconnected criteria, stakeholders can make informed decisions that optimize the operational efficiency, economic viability, and social integration of BSF pilot projects, paving the way for successful scaling across Africa.

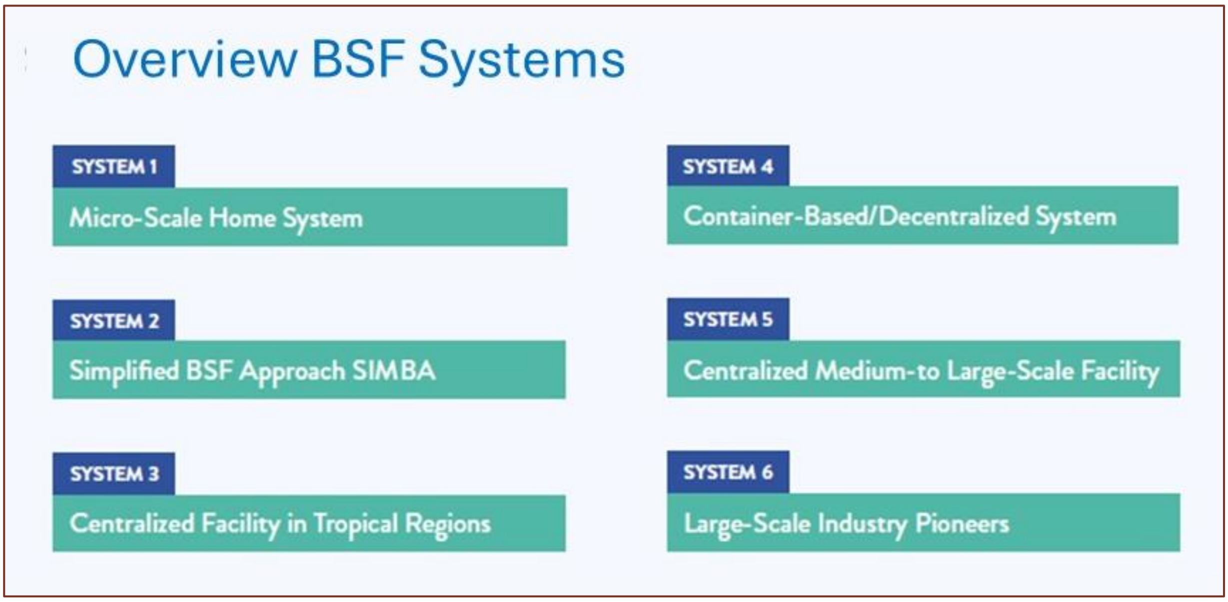
2.2.2 Overview about BSF rearing technologies

BSF system overview

The BSF technology offers remarkable versatility in its application, allowing for organic waste bioconversion and biomass production across a wide spectrum of scales. This inherent flexibility makes BSF rearing adaptable to diverse operational environments, ranging from small-scale, community-based initiatives to highly organized industrial facilities. This adaptability is particularly valuable in varied contexts, including those found across Africa, where localized waste streams and differing resource availability necessitate tailored solutions. The choice of rearing system is not merely a technical decision but a strategic one, influencing capital requirements, operational complexity, and the potential for scaling BSF operations to meet specific waste management and protein production demands.

There are different categories of BSF systems, as summarised in Figure 2-1. A short description for each type of system is provided below.

Figure 2-1: Overview BSF Systems (adapted)



Source: CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

Micro Scale Homy Systems

These simple, low-cost systems are ideal for individual or household use, offering a practical introduction to BSF technology for educational purposes. They're well-suited for small-scale waste management in both rural and urban backyards. This scale also supports the direct, on-site use of larvae or frass, making them perfect for schools or families with backyard poultry.

Simplified BSF approach SIMBA

This model is designed for small-scale operations, serving rural entrepreneurs and smallholder farmers. It emphasizes replicable processes that are easy to manage without needing advanced infrastructure or specialized expertise. By leveraging local resources and waste streams, farmers can develop a side business selling larvae or using them directly as animal feed.

Centralized facility in tropical regions

This system is specifically engineered for warm climates, where natural conditions minimize the need for costly climate control. It’s capable of processing large volumes of organic waste from diverse sources, including municipal waste, market discards, and agricultural by-products. These facilities often feature low-cost infrastructure, such as simple treatment beds, and can function as central hubs for both waste collection and BSF production. Examples of such facilities include Bioconvision in Uganda, LimaDOL in the Philippines, and Chanzi in Tanzania.

Container-based/decentralized system

These systems are modular and mobile, enabling flexible waste management in urban or semi-urban settings. Their containerized nature allows deployment at various locations, processing waste close to its source. This approach reduces transportation costs and emissions while ensuring efficient waste treatment. Such systems are especially beneficial for businesses or municipalities managing distributed waste streams. For instance, Reploid utilizes empty agricultural structures to create decentralized BSF facilities, with other examples of decentralized systems including Flybox, LIVIN farms, and Manna Insect.

Centralized medium-to large-scale facility

These systems are designed to manage significant waste volumes, necessitating standardized processes like automated feeding and harvesting. They are well-suited for urban or industrial areas characterized by high waste generation and accessible markets for BSF products. While requiring substantial investment, these operations achieve economies of scale and deliver consistent outputs, which makes them appealing to investors. Examples include the Chilean company F4F, which processes approximately 30 tonnes of waste daily, and facilities like Entobel in Vietnam and Chanzi in Tanzania.

Large-scale industry pioneers

These high-tech, automated facilities represent the pinnacle of industrial BSF production. Engineered for maximum efficiency, they integrate cutting-edge technologies like robotics and advanced climate control. Such facilities support large-scale operations primarily targeting international markets, including aquafeed manufacturers and pet food companies. While demanding significant expertise and investment, they offer the promise of high productivity and profitability. Agronutris, Protix, and EnviroFlight are key examples within this category.

Centralized versus decentralized BSF projects

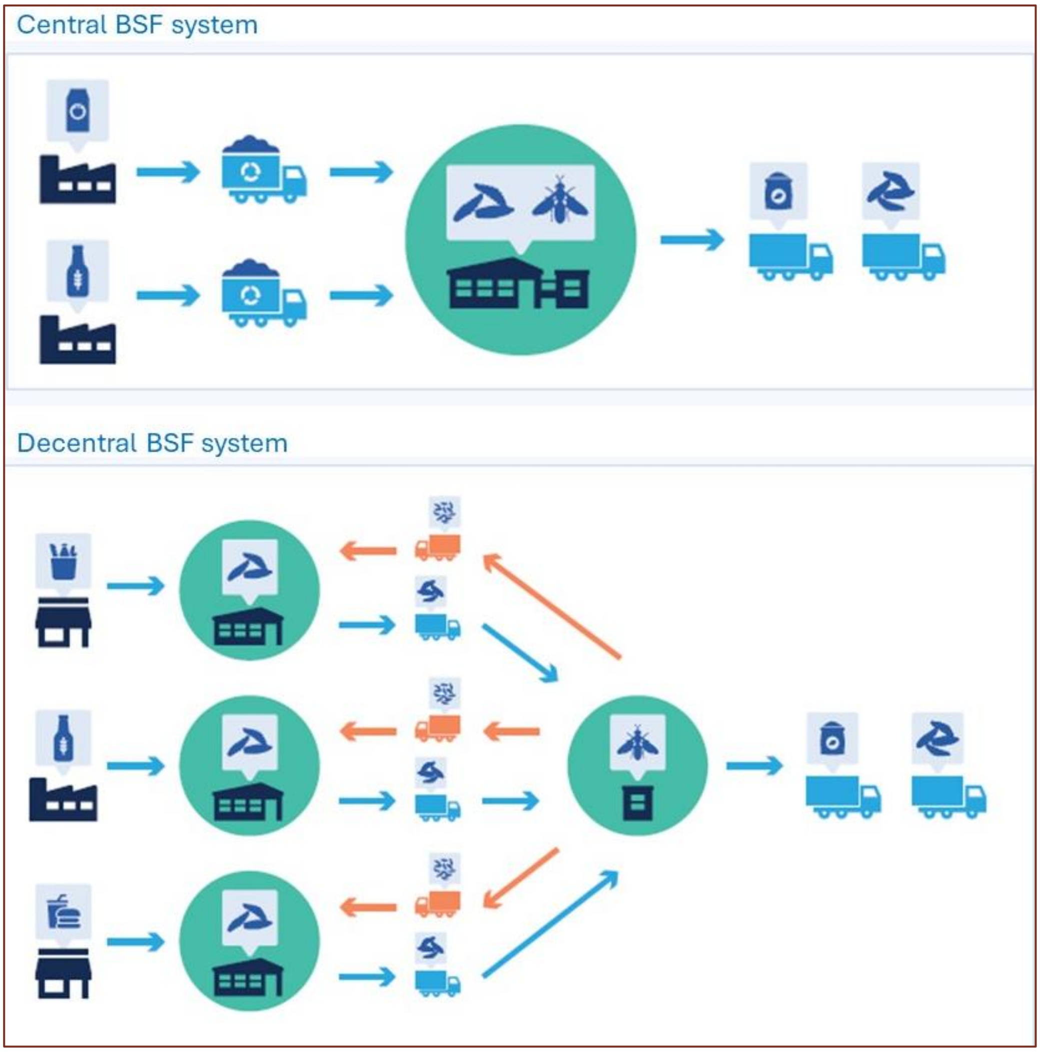
Differentiating between centralized and decentralized BSF plant models is crucial for optimizing logistics and operational efficiency. In a centralized model, the entire BSF processing chain, from substrate intake to product harvesting, occurs at a single location. This approach allows for the optimal mixing of diverse waste streams and leverages economies of scale for plant components. However, it necessitates significant transportation of organic waste, which typically consists of 70-80% water, making proximity to large substrate suppliers essential, or requiring the delivery of dry substrates or the charging of a waste acceptance fee.[35] Conversely, decentralized models involve waste treatment either directly at the waste producer's premises or at collection centres within a limited radius. In this setup, young larvae are typically supplied from a central breeding facility, and products (larvae and frass) are often collected and processed centrally. This significantly reduces the bulk transport of raw organic waste, limiting long-distance logistics primarily to the delivery of young larvae and the collection of finished products. The choice between these models largely hinges on transport

[35] CGIAR & International Water Management Institute (2020). Global Experiences on Waste Processing with Black Soldier Fly (Hermetia illucens): From Technology to Business.

costs, the existing infrastructure for larvae production and product processing, and important considerations regarding the ownership of decentralised bioconversion units.[36]

Figure 2-2 shows illustrations of examples of one central and one decentralized BSF system. The flexibility of the technology allows all types of adaptations in order to design a tailor-made BSF system for a specific context.

Figure 2-2: Central versus decentral BSF system (adapted)



Source: CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

[36] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems

2.2.3 Overview about operational aspects for a BSF facility

Effective management of BSF rearing operations requires careful attention to several key operational aspects. From feedstock preparation to product harvesting and ongoing performance monitoring, optimizing these processes is essential for achieving both efficiency and economic viability. This section outlines the critical operational considerations for a BSF facility.

Development of feeding protocols

The choice and preparation of substrate are critical factors of a BSF operation's efficiency and sustainability. BSF larvae are known for their ability to process a wide variety of organic materials, but their growth rate and the nutritional content of the resulting biomass are highly dependent on the quality and type of feed.[37]

Effective feeding protocols involve:

- **Substrate selection:** Identifying ideal substrates such as fruit and vegetable waste, agro-industrial by-products, food scraps, and brewer's spent grains, which are nutritionally rich and easily digestible. Materials with high cellulose, lignin content (e.g., wood, straw, paper), or toxic substances (heavy metals, pesticides, high salt/acid content) should be avoided as they can harm larvae and reduce productivity.[38]
- **Feedstock consistency and logistics:** Ensuring a consistent supply of feedstock is a key factor. Operators must consider the availability and seasonality of organic waste streams and may need to diversify suppliers or establish long-term supply contracts. In urban settings, access to source-separated organic waste from markets can be particularly beneficial.[39]
- **Pre-processing:** Preparing the raw waste for larval consumption often requires pre-processing steps, such as sorting to remove inorganic contaminants, shredding to increase surface area, and potentially adjusting moisture content. These steps enhance substrate accessibility for the larvae, impacting overall conversion efficiency and facility performance.

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[37] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.
[38] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.
[39] EAWAG (2017). Black Soldier Fly Biowaste Processing - A Step-by-Step Guide.

Larvae harvesting and processing techniques

After the larval stage, which typically lasts 10–14 days, the BSF larvae are ready for harvest.

Effective harvesting and processing techniques are essential to maximize the yield of valuable products:

- **Harvesting methods**: BSF larvae naturally "self-harvest" as they enter the prepupal stage, seeking a dry place to pupate. This behaviour can be leveraged by designing rearing systems with ramps or migration points that separate the larvae from the residual substrate, simplifying collection.40 Other methods may involve manual separation or sieving for continuous systems. Sieving is the most common practice for larvae harvesting.
- **Processing into valuable products**: Depending on market demand and regulatory frameworks, harvested larvae can be processed into various high-value products:[41]
    - Live/fresh larvae (also called wet larvae): For immediate feeding to animals, though they have a short shelf life.
    - Frozen fresh larvae/larval pulp: To extend shelf life, particularly for pet food.
    - Dried larvae: A common method to produce a shelf-stable product with reduced storage costs.
    - Protein meal: Achieved through defatting processes, increasing protein content for use in animal feed (e.g., aquaculture, poultry).
    - Fat: Extracted fat has potential applications in feed, cosmetics, or biofuel production, often high in lauric acid.

Frass management and utilization strategies

Frass, the residual material left after BSF larvae consume organic waste, is a significant co-product with growing market potential. It is mainly composed of the excrements of the larvae, skin from larvae and unprocessed organic waste. It is produced in large quantities (15–50% of feedstock input at around 50% moisture content; moisture content depends on process parameters and type of used organic waste) and is a nutrient-dense soil conditioner.[42]

Effective management and utilization strategies include:

- **Harvesting and processing:** Frass is typically separated from the larvae during harvest. Further processing might involve drying to reduce moisture content, sieving to achieve a consistent particle size, or pelletisation for ease of application and storage.
- **Stabilisation:** While BSF bioconversion stabilizes organic matter, further stabilization methods like composting or vermicomposting can enhance its quality and nutrient profile for specific agricultural applications.

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[40] EAWAG (2017). Black Soldier Fly Biowaste Processing - A Step-by-Step Guide.

[41] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

[42] EAWAG (2017). Black Soldier Fly Biowaste Processing - A Step-by-Step Guide.

- **Application as a biofertilizer:** Frass contains essential plant nutrients like nitrogen, phosphorus, and potassium (NPK), comparable to compost or biogas digestate. It can improve soil health, enhance crop growth, and contribute to sustainable agricultural practices. Its market potential is growing, especially in regions with demand for organic fertilizers.
- **Other uses:** Depending on local markets, frass can also be used to produce biochar through pyrolysis or to generate biogas via anaerobic digestion, offering additional revenue streams.[43]

Monitoring and evaluation framework

Establishing a robust monitoring and evaluation (M&E) framework is essential for tracking the performance, efficiency, and overall impact of a BSF facility, especially during pilot implementation. The generated data is relevant for optimizing the system and for a large-scale roll out of the BSF solution.

[43] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

This framework should involve key performance indicators (KPIs) to assess operational, environmental, and economic aspects. An overview of key operational, environmental and economic KPIs is provided in Table 2-1.

Table 2-1 List of potential key performance indicators

Example indicator	Possible measurement
Operational KPIs	
Waste reduction rate	Percentage of organic waste converted by larvae (e.g., up to 80% volume reduction).
Bioconversion rate	Percentage of wet larvae produced from a certain amount of input organic substrate.
Larval biomass gain	The increase in larval weight over the feeding period.
Feed conversion ratio (FCR)	Amount of feed consumed per unit of larval weight gain.
Frass production rate	Volume or weight of frass produced per unit of waste input.
Cycle time	Duration of the larval rearing cycle from egg to harvest.
Environmental KPIs	
GHG emission reduction	Quantifying the reduction in methane and other emissions compared to traditional waste disposal methods.
Resource efficiency	Tracking water and energy consumption per unit of product.
Nutrient recovery	Measuring the capture of nutrients from waste into biomass and frass.
Economic KPIs	
Production costs	Cost per kg of larvae or protein meal produced.
Revenue streams	Income generated from larvae, frass, and any other by-products.
Return on investment (ROI)	Financial viability and profitability of the operation.
Job creation	Number of direct and indirect employment opportunities generated.

Source: CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.; EAWAG (2017). Black Soldier Fly Biowaste Processing - A Step-by-Step Guide.

Regular monitoring of these KPIs allows for timely adjustments to operational protocols, identification of areas for improvement, and demonstration of the project's sustainability and economic viability to stakeholders and potential investors.

2.3 Phase 3: Scaling & Monitoring

2.3.1 Aligning with and influencing national strategies for BSF adoption

For BSF initiatives to scale effectively and achieve widespread impact, it is crucial for implementers and the BSF sector to actively engage with and align their efforts with existing or emerging national strategies. This involves understanding how BSF technology naturally integrates with broader national goals in waste management, agricultural development, and climate action, and subsequently contributing to or advocating for policies that explicitly recognize and support BSF adoption. BSF technology offers a compelling solution that aligns with multiple national strategic objectives. In waste management, BSF systems provide a decentralized and efficient method for diverting organic waste from landfills, thereby reducing pollution and extending landfill lifespans.[44] From an agricultural policy perspective, BSF products, particularly protein-rich larvae and nutrient-dense frass, offer sustainable alternatives to conventional feed ingredients and chemical fertilizers, contributing to food security and resilient agricultural practices.[45] Furthermore, BSF's role in converting organic waste minimizes methane emissions—a potent short-lived climate pollutant—making it a vital component in national climate action plans and NDCs.

Implementers play a vital role in shaping the strategic landscape. Their contributions can include:

- **Demonstrating impact:** Providing robust data and case studies from pilot projects that clearly showcase BSF's effectiveness in waste reduction, economic value creation, and GHG emission mitigation.
- **Participating in policy dialogues:** Actively engaging in consultations, workshops, and multi-stakeholder platforms where national waste, agriculture, and climate strategies are developed or reviewed. This ensures that the unique benefits and needs of the BSF sector are heard and considered.
- **Providing technical expertise:** Sharing practical knowledge on BSF rearing, processing, and market dynamics to inform realistic and effective policy design.
- **Advocating for explicit inclusion:** Championing the explicit mention and prioritization of BSF technology within national policy documents, potentially leading to dedicated funding, simplified regulations, and institutional support.

By strategically aligning their initiatives and proactively influencing policy development, BSF implementers can unlock significant government support, streamline operational hurdles, and accelerate the widespread adoption of BSF technology as a key enabler for sustainable development.

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[44] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

[45] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.; EAWAG (2017). Black Soldier Fly Biowaste Processing - A Step-by-Step Guide.

2.3.2 Navigating and advocating for supportive regulatory frameworks and standards

For BSF initiatives to transition successfully from pilot projects to scaled operations, implementers must actively navigate and contribute to the evolution of supportive regulatory frameworks and industry standards. As a relatively nascent sector, BSF technology often operates within a complex landscape where existing regulations, designed for conventional agriculture or waste management, may not fully accommodate its unique characteristics.

Understanding and complying with existing regulations:

The first step for BSF implementers is to thoroughly understand the current regulatory environment that impacts their operations. This typically involves legislation related to:

- **Waste management:** Rules governing the collection, transportation, processing, and disposal of organic waste.
- **Animal feed and food safety:** Regulations concerning the safety and quality of BSF larvae and their derived products (e.g., protein meal, fat) when used in animal feed, and potentially in human food.[46]
- **Fertilizer and soil amendments:** Standards for the production, quality, and application of BSF frass.
- **Environmental protection:** Guidelines on emissions, wastewater discharge, and nuisance control (e.g., odour, pests).
- **Trade and cross-border movement:** Regulations impacting the import and export of BSF products, particularly relevant for regional markets in Africa.

Even in the absence of specific BSF regulations, implementers are obligated to comply with all applicable general laws. Proactive compliance helps build trust with authorities and demonstrates a commitment to responsible operations.

Actively engaging with policymakers and advocating for BSF-specific guidelines:

Beyond mere compliance, implementers have a crucial role in advocating for the development of clear, enabling, and BSF-specific regulatory frameworks. This active engagement is vital for several reasons:

- **Reducing uncertainty:** Ambiguous or absent regulations can deter investment and hinder expansion. Clear guidelines provide legal certainty and predictability for businesses.[47]
- **Tailoring standards:** Existing regulations might not be optimized for BSF processes or products. Implementers can provide expert input on appropriate standards for substrate safety, processing methodologies, and end-product quality that are scientifically sound and commercially viable.

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[46] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

[47] FAO (2023). Mapping of the Black Soldier Fly value chain in East Africa.

- **Streamlining processes:** Advocating for simplified licensing, permitting, and approval processes can significantly reduce bureaucratic delays that often impede the speed of scale-up.
- **Unlocking market access:** Supportive regulations are critical for ensuring that BSF products can be legally used and traded in target markets, both domestically and internationally. This includes establishing BSF as a recognized and safe feed ingredient or fertilizer.

Implementers can advocate through various channels, including industry associations, research collaborations, pilot project demonstrations, and direct dialogues with relevant government ministries and regulatory bodies. By presenting well-researched proposals and demonstrating the environmental and economic benefits of BSF, the sector can effectively influence the creation of a regulatory environment conducive to widespread adoption and innovation. This proactive approach helps to de-risk investments and foster a predictable landscape for scaling BSF operations in various contexts, including across African nations where regulatory frameworks for novel waste valorisation technologies may be nascent.

2.3.3 Fostering public-private partnerships for BSF scale-up

Scaling BSF initiatives from pilot projects to widespread adoption requires strong collaborative efforts. Public-private partnerships (PPPs) are an essential mechanism for pooling diverse resources, sharing risks, and leveraging complementary expertise to drive the expansion of the BSF sector. These collaborations bring together BSF operators, government entities, private sector actors (beyond BSF production), and research institutions to address common challenges and accelerate growth.

The strategic importance of PPPs

In an emerging industry like BSF, PPPs are critical for overcoming common hurdles such as access to sufficient capital, securing consistent feedstock supply, developing robust regulatory frameworks, and ensuring market access for BSF products. By combining the public sector's role in policy, regulation, and waste management infrastructure with the private sector's innovation, operational efficiency, and market orientation, these partnerships create a more robust and predictable environment for investment and growth.[48]

Strategies and mechanisms for building effective collaborations:

Implementers and stakeholders in the BSF sector can foster impactful PPPs through various strategies and mechanisms:

- **Joint project development:** Initiating collaborative pilot projects where public entities provide access to waste streams or land, while private operators bring technical expertise and investment.

[48] FAO (2023). Mapping of the Black Soldier Fly value chain in East Africa.

- **Formal agreements and consortia:** Establishing Memoranda of Understanding (MoUs), joint ventures, or consortia for larger-scale BSF facilities that require shared funding, infrastructure development, or multi-stakeholder management.
- **Shared knowledge platforms:** Creating forums or working groups where BSF operators, government representatives, and researchers can regularly exchange information on best practices, technological advancements, and market insights.
- **Co-funding research and development (R&D):** Public and private entities can jointly fund research into optimized BSF rearing, processing technologies, and new product development, bridging the gap between scientific discovery and commercial application.
- **Incentive alignment:** Working with government bodies to design and implement financial or non-financial incentives (e.g., waste acceptance fees, tax breaks) that benefit both public waste management goals and private sector profitability in BSF operations.
- **Capacity building initiatives:** Collaborating on the design and delivery of training programs that are supported by government agencies, informed by industry needs, and delivered by research institutions, ensuring a skilled workforce for the expanding sector.
- **Value chain integration:** Partnering with established private sector actors in agriculture (e.g. feed mills, fertilizer distributors, large farms) to integrate BSF products into existing supply chains, thereby securing off-take markets.

By actively seeking and nurturing these multi-faceted partnerships, BSF implementers can de-risk their investments, accelerate innovation, expand market reach, and significantly contribute to sustainable waste management and circular economy principles, especially in regions like Africa where such collaborative models can drive inclusive growth.

2.3.4 Implementing capacity building and training programs

Scaling up the BSF industry depends also on the availability of a skilled and knowledgeable workforce across the entire value chain. Therefore, actively designing, delivering, and expanding robust educational and training initiatives is a critical responsibility for implementers within the BSF sector. These programs are essential to bridge existing knowledge gaps, foster best practices, and ensure the quality and safety of BSF products as operations expand.

Why capacity building is essential for scaling?

The BSF industry is relatively new, and a lack of experience and comparative cases can pose significant challenges to achieving profitability and sustainability.[49]

Comprehensive training addresses this by:

[49] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

- **Building technical proficiency:** Ensuring that personnel understand the intricate biological and operational aspects of BSF rearing, from egg to adult fly.
- **Promoting efficiency and quality:** Standardizing procedures for feeding, harvesting, and processing, which leads to more consistent product outputs and higher yields.
- **Fostering innovation:** Equipping individuals with the knowledge to adapt technologies, optimize processes, and troubleshoot challenges specific to their local context.
- **Ensuring safety and compliance:** Educating staff on hygiene, product safety standards, and regulatory requirements, which is vital for market acceptance.

Designing and delivering effective programs

Successful capacity building programs require a strategic approach, considering various stakeholders and their specific needs:

- **Target audience identification:** Training initiatives must cater to diverse groups across the BSF value chain. This includes BSF farm operators and technicians (focused on rearing, feeding, harvesting, and processing), waste management personnel (on waste sorting and pre-treatment), local entrepreneurs and business managers (on facility economics, market analysis, and product commercialization), and even end-users like farmers (on the effective application of BSF-based feeds and fertilizers).
- **Curriculum development:** Programmes should feature practical, hands-on training complemented by theoretical knowledge. Content should be tailored to local contexts, considering local BSF strains, locally available feedstocks, and relevant socio-economic conditions. This can range from basic BSF biology and colony management to advanced plant operation and quality control.
- **Delivery methodologies:** A blend of approaches can maximize learning and accessibility. This includes structured workshops, masterclasses, on-site demonstrations at operational BSF facilities, practical internships, and potentially digital learning modules for wider reach. Collaborating with vocational training centres, agricultural colleges, and local universities can enhance program credibility and reach.
- **Train-the-trainer models:** Developing local experts who can then disseminate knowledge within their communities or organizations is a highly effective way to expand training capacity sustainably.

Expanding and sustaining training initiatives

As the BSF sector scales, so too must its capacity-building efforts. Implementers can contribute to this expansion by:

- **Establishing regional training hubs:** Partnering with established BSF facilities or educational institutions to create centres of excellence that offer specialized training.

- **Developing certification programmes:** Implementing standardized certification for BSF technicians and operators to validate skills and promote professionalism.
- **Facilitating continuous learning:** Creating platforms for ongoing knowledge exchange, mentorship, and professional development to keep pace with industry advancements.

By investing in robust capacity building and training, implementers directly strengthen the human capital necessary for the BSF industry to achieve its full potential in waste valorisation, sustainable agriculture, and economic empowerment across various scales.

2.3.5 Fostering public awareness and acceptance of BSF technology

Successful scaling of the BSF technology depends not only on technical and economic viability but also significantly on its social acceptance. Developing and deploying effective communication strategies is crucial for educating the public about the benefits, safety, and diverse applications of BSF technology, thereby increasing social acceptance and ultimately stimulating market demand for its products.

Why public awareness is crucial for scale-up?

Despite its immense potential, BSF technology can face initial skepticism or unfamiliarity from the public, particularly regarding insects as a resource. Addressing misconceptions and building trust is paramount for securing a "social license to operate" for BSF facilities and fostering demand for BSF-derived products like animal feed and organic fertilizer.[50] Awareness campaigns build confidence among consumers, local communities, and potential end-users, facilitating smoother integration into various sectors.

Key messages for effective communication:

Communication strategies should highlight the multifaceted advantages of BSF technology using clear, accessible language:

- **Environmental benefits:** Emphasize BSF's role in diverting organic waste from landfills, significantly reducing of GHG emissions (especially methane) and contributing to circular economy principles.[51]
- **Economic value:** Showcase the creation of high-value products (protein for animal feed, fat, and nutrient-rich frass), job creation, and sustainable livelihood opportunities, particularly in rural and urban areas.
- **Safety and quality assurance:** Clearly communicate the rigorous production and hygiene standards employed in BSF facilities, ensuring product safety and quality for intended applications. This helps to alleviate concerns about novel ingredients.

[50] FAO (2023). Mapping of the Black Soldier Fly value chain in East Africa.
[51] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

- **Natural and sustainable process:** Frame BSF as nature's efficient recyclers, performing a vital ecosystem service that converts waste into valuable resources.
- **Diverse applications:** Illustrate how BSF products contribute to sustainable aquaculture, poultry farming, pet food, and improved soil health.
- **Feed benefits:** Improved health of animals, greater protein conversion, lower mortality rates, reduced need for antibiotics and hormones.

Developing and deploying communication strategies:

BSF implementers play an active role in designing and executing targeted communication efforts:

- **Target audience identification:** Tailoring messages and channels to specific groups, including local communities, farmers, consumers, retailers, and educational institutions. For instance, farmers might be interested in performance benefits, while consumers might prioritize sustainability and safety.
- **Community engagement:** Organizing open days at BSF facilities, conducting local meetings, and establishing accessible points of contact to foster direct dialogue and address concerns.
- **Educational outreach:** Partnering with schools, universities, and vocational training centers to integrate BSF into environmental and agricultural curricula, fostering awareness from a young age.
- **Multi-channel communication:** Utilizing a mix of communication channels, including digital platforms (social media, websites, educational videos), traditional media (radio, television, newspapers), and printed materials (brochures, fact sheets).
- **Influencer and ambassador programs:** Collaborating with trusted local leaders, agricultural experts, or respected community members to disseminate information and endorse the technology.
- **Clear marketing:** Highlighting the sustainable and beneficial attributes of BSF-derived products directly on packaging/marketing materials to inform consumers.

By proactively educating the public and fostering acceptance through transparent and engaging communication, BSF implementers can build strong community relations, cultivate market demand, and pave the way for broader adoption and growth of the BSF sector.

2.3.6 Supporting innovative BSF entrepreneurship and niche market development

Fostering a vibrant ecosystem of innovative BSF entrepreneurs is crucial for the widespread scaling and diversification of the sector. While large industrial facilities attract significant investment, smaller and medium-scale ventures, often driven by local entrepreneurs, play a vital role in addressing localized waste challenges, creating jobs, improving food security, and exploring specialized market opportunities.[52] Supporting these entrepreneurs involves

[52] CGIAR & International Water Management Institute (2020). Global Experiences on Waste Processing with Black Soldier Fly (Hermetia illucens): From Technology to Business.

creating opportunities and providing targeted mechanisms to help them establish, grow, and identify profitable niches within the BSF value chain.

The importance of entrepreneurship in BSF scaling

Entrepreneurs bring agility, localized knowledge, and a willingness to innovate, which are essential for adapting BSF technology to diverse contexts, particularly in regions with varied waste streams and market dynamics. They can identify specific local needs and develop tailored solutions, driving sector growth from the ground up and diversifying the range of BSF-derived products and services.[53] Furthermore, insect farming offers opportunities for women and youth, contributing to economic empowerment and inclusive growth.[54]

Creating opportunities and providing support mechanisms

To enable BSF entrepreneurs to thrive, a supportive environment must be cultivated through various mechanisms:

- **Incubation and acceleration programmes:** Providing dedicated physical spaces, shared infrastructure (e.g., small-scale processing units, laboratory access), and structured programs that offer technical guidance, business development training, and mentorship. These programs help entrepreneurs refine their business models and overcome initial hurdles.
- **Mentorship networks:** Connecting aspiring BSF entrepreneurs with seasoned industry veterans, business leaders, and technical experts who can offer practical advice, share experiences, and guide strategic decision-making.
- **Facilitated access to resources:**
    - **Funding:** Helping entrepreneurs navigate the landscape of seed capital, angel investments, microfinance, and grant opportunities tailored for sustainable agribusiness or waste management.
    - **Feedstock:** Establishing clear pathways for entrepreneurs to access consistent and suitable organic waste streams from local markets, agricultural operations, or industrial by-products.
    - **Technology and knowledge transfer:** Promoting access to open-source BSF rearing designs, low-cost equipment solutions, and best practices to reduce initial setup costs and operational risks.
    - **Market linkages:** Proactively connecting entrepreneurs with potential buyers for larvae, frass, or processed products, including off-take agreements that provide market certainty.

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[53] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

[54] Chineme, A., et al. (2022). African Indigenous Female Entrepreneurs (IFÉs): A Closed-Looped Social Circular Economy Waste Management Model.

- **Networking platforms:** Organizing workshops, industry events, and online communities where entrepreneurs can connect with peers, exchange ideas, form collaborations, and learn from collective experiences.

Identifying and serving niche markets

Beyond the large-volume commodity markets (like aquafeed and poultry feed), supporting entrepreneurs in identifying and serving niche markets can significantly enhance profitability and sustainability. These specialized markets often have lower volume requirements but higher profit margins, making them accessible entry points for smaller-scale operations.

Examples of such niches include:

- **Pet food:** Supplying live or processed BSF larvae for ornamental fish, reptiles, singing birds, or specialized pet diets, where consumers are often willing to pay a premium for sustainable and high-quality ingredients.[55]
- **Specialty fertilizers:** Developing and marketing BSF frass as a premium organic fertilizer for specific crops, horticulture, or gardening, leveraging its unique nutrient profile.
- **Research and development products:** Providing BSF larvae or derivatives for research purposes in academia or other industries.
- **Direct-to-farm models:** Supplying larvae directly to smallholder farmers for on-farm feed production or waste conversion, often reducing transportation costs and strengthening local circular economies.

By strategically nurturing BSF entrepreneurship and facilitating access to niche markets, the sector can foster innovation, create diverse revenue streams, and ensure its adaptability and resilience as it scales.

[55] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

Policy recommendations

3 Policy recommendations for enabling BSF implementation and enhancing NDCs

3.1 Integrating BSF into national climate and waste strategies

The widespread adoption of BSF technology as a sustainable solution for organic waste management and resource recovery requires its explicit and strategic integration into national climate change and waste management frameworks. Governments have a critical role in formalizing BSF's position within these overarching strategies to unlock its full potential for environmental benefits and economic growth.

3.1.1 Explicitly including BSF-based organic waste management in national policies and NDCs

It is recommended that governments should formally recognize BSF bioconversion as a priority technology within national waste management policies, organic waste diversion strategies, and broader circular economy roadmaps. This involves:

- **Policy mandates:** Incorporating specific provisions that encourage or mandate the use of BSF technology for the treatment of various organic waste streams, such as food waste, agricultural residues, and market waste.
- **Strategic alignment:** Clearly articulating how BSF implementation contributes to national development goals related to waste reduction, resource efficiency, sustainable agriculture, and job creation within official policy documents.
- **NDC enhancement:** Explicitly including BSF-based organic waste treatment as a key mitigation action in updated NDCs under the Paris Agreement.[56] This formal inclusion signals a country's commitment to leveraging innovative solutions for climate action and can attract international climate finance.

3.1.2 Setting targets for organic waste diversion and quantifying GHG emission reductions

To drive measurable progress, policies should establish clear and ambitious targets for organic waste diversion through BSF technology. This goes hand-in-hand with robust methodologies for quantifying the GHG emissions reductions achieved:

- **Quantifiable targets:** Setting specific, measurable, achievable, relevant, and time-bound (SMART) targets for the percentage or tonnage of organic waste to be processed by BSF systems nationally or regionally.
- **Methodology development:** Investing in or adopting standardized methodologies for quantifying GHG emission reductions, particularly methane, resulting from BSF-based organic waste treatment compared to conventional disposal methods (e.g.,

[56] UNFCCC (2025). Nationally Determined Contributions (NDCs) - The Paris Agreement and NDCs.

landfilling).[57] These methodologies should be compatible with international reporting standards for NDCs.

- **Baselines and scenarios:** Developing national baselines for organic waste generation and disposal, along with scenarios that project emission reductions achievable through scaled BSF adoption.

3.1.3 Formal recognition and definition of BSF products

A critical step for integrating BSF is to officially recognize and define BSF-derived products (e.g., BSF meal, oil, frass) within national legal frameworks. This means:

- **Clear classification:** Establishing clear legal classifications for BSF larvae and their derivatives as legitimate feed ingredients, fertilizers, or other commercial products, rather than categorizing them as waste.
- **Product standards:** Collaborating with industry and research institutions to develop specific quality and safety standards for BSF products, ensuring they meet national and international requirements for animal feed, fertilizer, and potential other applications.

3.1.4 Promoting inter-ministerial coordination

Given BSF's cross-cutting benefits across waste, agriculture, and environment sectors, effective integration requires strong coordination across relevant government ministries and agencies:

- **Cross-Sectoral working groups:** Establishing inter-ministerial working groups or task forces to develop integrated policies and overcome siloed approaches.
- **Joint action plans:** Encouraging the development of joint action plans that ensure coherence and synergy between national waste management, agricultural development, and climate change adaptation/mitigation strategies.

3.1.5 Enabling funding and incentive mechanisms

Policies should pave the way for dedicated financial support and incentives that encourage investment in BSF technology:

- **Dedicated funding streams:** Allocating national budget lines or establishing dedicated funds for BSF projects, potentially drawing from climate finance, green bonds, or waste management levies.
- **Fiscal incentives:** Implementing tax breaks, subsidies, or preferential loan schemes for BSF enterprises, particularly for those integrating local communities and supporting sustainable practices.
- **Waste acceptance fees (Gate fees):** Policy support for waste acceptance fees at BSF facilities, creating a sustainable revenue stream for operators and incentivizing waste diversion.

[57] CCAC (2025). Elevating Waste Solutions: Biocovers and Black Soldier Fly Technology.

3.1.6 Establishing robust data collection and MRV systems

To validate the environmental and economic benefits, and to inform future policy, national strategies should mandate or support robust data collection and Measurement, Reporting, and Verification (MRV) systems:

- **Standardized data collection:** Implementing protocols for BSF facilities to consistently collect data on waste input, BSF biomass and frass output, energy consumption, and other relevant operational metrics.
- **National reporting:** Integrating BSF performance metrics into national environmental and climate reporting frameworks, ensuring that BSF's contribution to NDC targets is accurately tracked and communicated.

By implementing these comprehensive policy recommendations, national governments can create a strong enabling environment for BSF technology, positioning it as an important component in achieving sustainable waste management, enhancing climate resilience, and fostering a functioning circular economy.

3.2 Supporting local governments in BSF implementation

Local governments are at the forefront of urban and rural waste management, making their engagement and capacity crucial for the successful national-level scaling of the BSF technology. National policies must therefore prioritize direct support to local authorities, empowering them to integrate BSF solutions effectively into their municipal waste management systems.

3.2.1 Providing financial and technical assistance to local authorities

National governments should establish dedicated mechanisms to provide both financial and technical assistance to local authorities interested in establishing BSF processing facilities. This direct support mitigates the initial investment burden and knowledge gaps often faced by municipalities:

- **Financial resources:** Offering grants, matching funds, or low-interest loans specifically earmarked for feasibility studies, pilot BSF projects, and the construction or upgrade of BSF processing infrastructure. This can include support for procuring necessary equipment and developing site-specific plans.
- **Technical expertise:** Deploying expert teams or funding access to consultants who can provide guidance on BSF facility design, operational protocols, waste stream characterization, and the integration of BSF within existing waste collection logistics.[58] Assistance should also extend to market analysis for BSF products to ensure sustainability.

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[58] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

- **Capacity development funding:** Supporting the training of local municipal staff in BSF operations, management, and monitoring, ensuring that local expertise is developed and retained.

3.2.2 Developing guidelines and best practices for integrating BSF into municipal waste management systems

To ensure consistency, efficiency, and scalability, national governments should develop comprehensive guidelines and best practices tailored for municipal-level BSF implementation. These resources should be adaptable to diverse local contexts:

- **Standardized integration roadmaps:** Providing clear frameworks for how BSF facilities can be seamlessly integrated into existing municipal waste collection, sorting, and transfer stations. This includes guidance on feedstock quality control at the municipal level.
- **Operational blueprints:** Developing adaptable models for various scales of BSF operations—from decentralized community-based units to larger municipal facilities—offering technical specifications and operational best practices.
- **Environmental and social impact assessment templates:** Furnishing tools and methodologies for local governments to conduct thorough environmental and social impact assessments for proposed BSF sites, ensuring community acceptance and compliance with national regulations.
- **Product utilization guidance:** Providing clear recommendations on how BSF products (larvae and frass) can be utilized within the local agricultural sector or marketed to local businesses, helping municipalities realize the full value of the BSF process.

3.2.3 Facilitating knowledge sharing and networking among local governments

To accelerate learning and foster a collaborative environment, national policies should actively facilitate knowledge exchange and networking opportunities among local governments implementing or considering BSF solutions:

- **Peer-Learning platforms:** Establishing national or regional platforms, forums, and workshops where municipal leaders and waste managers can share experiences, discuss challenges, and showcase successful BSF projects.
- **Study tours and exchange programs:** Organizing visits to operational BSF facilities in other municipalities or countries, allowing local officials to gain practical insights and observe best practices firsthand.
- **Online resource hubs:** Creating centralized digital repositories of case studies, technical documents, research findings, and contact information for experts and successful BSF implementers, making information readily accessible.
- **Mentorship initiatives:** Connecting municipalities with nascent BSF programs to those with established, successful operations for direct mentorship and guidance.

By investing in and strategically supporting local governments, national authorities can ensure that BSF technology is effectively deployed at the community level, leading to more sustainable waste management, improved local economies, and tangible contributions to national climate goals.

3.3 Regulatory and incentive mechanisms

To enable the significant scale-up BSF implementation, national governments must establish comprehensive and forward-looking regulatory and incentive mechanisms. These frameworks are critical for reducing investor risk, ensuring product safety, fostering market development, and accelerating the adoption of BSF technology across the waste management and agricultural sectors.

3.3.1 Developing clear and supportive regulatory frameworks for BSF farming and product utilization

A primary policy intervention is to provide legal clarity for BSF operations and their products. This involves:

- **Legal classification:** Formally recognizing BSF larvae and their derived products (meal, oil, frass) as valuable resources rather than waste or by-products in national legislation related to feed, food, and fertilizers. This is crucial for their integration into commercial markets.
- **Science-based regulations:** Ensuring that regulations are grounded in scientific evidence, proportionate to the risks, and designed to foster innovation without compromising safety. This includes defining permissible feedstocks, hygiene standards for rearing, and processing requirements.

3.3.2 Adopting BSF-specific standards

Beyond general frameworks, specific standards tailored to BSF products are essential for quality assurance and market trust:

- **Product quality standards:** Developing and implementing national standards for BSF meal (e.g., protein content, fat content, amino acid profile, contaminants), BSF oil, and particularly frass fertilizer safety. For frass, this should include guidelines on nutrient content, heavy metals, and pathogen limits to ensure its safe and effective application in agriculture.[59]
- **Testing and certification:** Establishing robust testing protocols and supporting national certification bodies that can verify compliance with these standards, providing confidence to buyers and consumers.

3.3.3 Streamlining licensing to reduce bureaucratic delays

Inefficient and complex licensing processes can be significant barriers to BSF implementation. Governments should prioritize streamlining these procedures:

[59] FAO (2023). Mapping of the Black Soldier Fly value chain in East Africa.

- **Single-window system:** Implementing a coordinated, single-window approval process for BSF facilities, integrating requirements from environmental, agricultural, health, and commercial ministries to reduce redundant applications and delays.
- **Clear timelines and checklists:** Publishing transparent checklists of requirements and guaranteed timelines for permit approvals to provide certainty for investors and entrepreneurs.
- **Digitalization:** Leveraging digital platforms for application submissions, tracking, and communication to enhance efficiency and transparency.

3.3.4 Implementing financial incentives to encourage investment in BSF technology

Direct financial and fiscal incentives are powerful tools to de-risk investments and stimulate growth in the BSF sector:

- **Subsidies and grants:** Providing targeted subsidies or grants for the establishment of new BSF facilities, particularly for pilot projects, small and medium-sized enterprises (SMEs), and those integrating local communities or processing challenging waste streams.
- **Tax benefits:** Offering tax breaks, reduced corporate taxes, or exemptions from import duties on specialized BSF equipment and technologies.
- **Preferential loans and guarantees:** Facilitating access to affordable financing through public or development banks, including loan guarantees that reduce lender risk.
- **Carbon credit integration:** Developing national methodologies or facilitating access to international carbon markets for BSF projects that demonstrably reduce methane emissions from organic waste, providing an additional income stream and incentivizing climate action.[60]

3.3.5 Creating market linkages and supporting the development of value chains for BSF-based products

Beyond production, policies should actively support the establishment of robust markets for BSF products:

- **Off-take agreements:** Encouraging and facilitating long-term procurement agreements between BSF producers and large consumers (e.g., aquaculture farms, poultry operations, large-scale agricultural cooperatives) to provide market certainty.
- **Market promotion and awareness:** Supporting public campaigns and industry initiatives that promote the nutritional and environmental benefits of BSF products to end-users and consumers.

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[60] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

- **Value chain development programs:** Investing in programs that support the entire BSF value chain, from sustainable feedstock sourcing to processing, distribution, and marketing.
- **Waste acceptance fee policy:** Enabling BSF facilities to charge appropriate waste acceptance fees, which serves as a critical revenue stream and provides a direct incentive for waste generators to divert organic waste from landfills.

By implementing these comprehensive regulatory and incentive mechanisms, governments can foster an enabling environment that attracts investment, encourages innovation, ensures product safety, and accelerates the widespread adoption of BSF technology as a cornerstone of sustainable waste management and circular bioeconomy.

3.4 Promoting research and development

Sustained growth and optimization of the BSF sector, particularly in diverse African contexts, depends on continuous investment in research and development (R&D). While foundational BSF knowledge exists, localized R&D is crucial for adapting technologies, optimizing practices, and unlocking new opportunities that are specific to regional conditions and challenges. Governments play a key role in fostering this research ecosystem.

3.4.1 Cooperation with local universities to accompany BSF projects scientifically

Establishing strong partnerships between BSF implementers, government bodies, and local universities and research institutions are crucial. This collaboration ensures that BSF projects are not only commercially viable but also scientifically robust, generating valuable data and insights. Mechanisms for this cooperation include:

- **Joint research initiatives:** Funding and facilitating collaborative research projects focused on optimizing BSF rearing and waste bioconversion under local conditions.
- **Student engagement:** Encouraging university students (undergraduate and postgraduate) to undertake research on BSF, providing them with practical experience and contributing to the body of knowledge. This can include thesis projects, internships, and field studies.
- **Scientific monitoring and evaluation:** Engaging academic institutions to provide independent scientific oversight and rigorous data analysis for BSF pilot and scaling projects, validating their environmental and economic impacts.
- **Knowledge transfer platforms:** Utilizing universities as hubs for disseminating research findings, organizing seminars, and hosting workshops to share scientific advancements with industry and policymakers.

3.4.2 Investing in local research to optimize BSF rearing practices for specific African contexts

Generic BSF rearing protocols may not be optimally suited for the unique environmental, social, and economic conditions prevalent across Africa. Therefore, targeted local research is essential to:

- **Optimize indigenous BSF strains:** Investigating and potentially breeding local strains of Hermetia illucens that are naturally adapted to specific African climates and resilient to local pathogens or environmental stressors. This can lead to more robust and productive colonies.
- **Evaluate locally available feedstocks:** Conducting comprehensive research on the suitability, nutritional conversion efficiency, and safety of diverse, locally abundant organic waste streams (e.g., specific crop residues, regional food processing by-products, varied municipal organic waste compositions). This ensures that BSF operations can utilize readily available and cost-effective inputs.
- **Adapt rearing conditions:** Researching optimal temperature, humidity, and ventilation strategies that leverage natural climatic advantages while minimizing the need for expensive, energy-intensive climate control systems in African settings.
- **Develop low-cost technologies:** Fostering innovation in the design and fabrication of affordable, locally manufacturable BSF rearing equipment and infrastructure suitable for various scales of operation, from smallholder to industrial.

3.4.3 Supporting innovation in BSF processing and byproduct development

R&D efforts should extend beyond primary rearing to encompass the entire BSF value chain, focusing on enhancing product quality, diversifying revenue streams, and improving post-processing efficiency:

- **Advanced processing techniques:** Researching and developing cost-effective and energy-efficient methods for processing BSF larvae into high-quality protein meal, oil, and other derivatives, ensuring they meet market specifications and safety standards.
- **Frass valorization:** Investing in research to fully understand the diverse applications and benefits of BSF frass as a biofertilizer for various soil types and crops common in African agriculture and exploring its potential for other uses like biogas or biochar production.
- **Novel by-product development:** Exploring the extraction and application of other valuable compounds from BSF, such as chitin, chitosan, and antimicrobial peptides, which could open up new high-value markets.
- **Waste-to-value chain optimization:** Researching integrated approaches that optimize the entire BSF waste-to-value chain, from efficient waste collection and pre-treatment to product marketing and distribution, ensuring economic viability and environmental sustainability.

By actively promoting and investing in this targeted R&D, governments and stakeholders can ensure that the BSF sector in Africa is built on a strong scientific foundation, leading to resilient, efficient, and locally adapted solutions that maximize both environmental and economic benefits.

3.5 Measuring and reporting SLCPs reduction through BSF

For the BSF technology to be fully recognized for its environmental contributions, particularly in climate change mitigation, governments must prioritize the development of robust frameworks for measuring, reporting, and verifying (MRV) the reduction of Short-Lived Climate Pollutants (SLCPs). This transparency is crucial for attracting climate finance, attracting investment, and ensuring BSF's demonstrable contribution to national climate goals.

3.5.1 Developing methodologies for quantifying methane emission reductions

A fundamental step is to establish standardized and scientifically credible methodologies for quantifying the reduction in GHG emissions achieved through BSF-based organic waste diversion. This involves:

- **Life Cycle Assessment (LCA) approach:** Encouraging the development of BSF-specific LCA methodologies that compare the GHG emissions from BSF organic waste treatment with those from conventional waste management practices, such as landfilling or composting.[61] This ensures a holistic accounting of emissions across the entire process.
- **Baseline and project scenario definitions:** Clearly defining baseline scenarios (what would happen to the organic waste without BSF) and project scenarios (emissions from BSF operations) to accurately attribute emission reductions to BSF implementation.
- **Data requirements:** Specifying the types of operational data (e.g., waste input volumes, moisture content, energy consumption, waste composition before and after BSF treatment) that BSF facilities must collect to enable accurate quantification.
- **Adaptation to local contexts:** Ensuring that methodologies are flexible enough to account for variations in waste streams, climate conditions, and operational scales prevalent in different regions, particularly across African countries.

3.5.2 Carbon credits for methane reduction and additional income streams

Quantifiable methane emission reductions from BSF projects present a significant opportunity to generate carbon credits, thereby creating an additional income stream and enhancing the economic viability of BSF investments. Governments can facilitate this by:

- **Developing suitable methodologies:** Supporting the development and approval of BSF-specific methodologies under recognized carbon credit standards (e.g., Voluntary Carbon Standard - VCS, Gold Standard - GS).[62] These methodologies provide the framework for projects to register, monitor, and issue verifiable carbon credits.

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[61] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

[62] VERRA (2024). Methodology for Black Soldier Fly Larvae Disposing of Organic Waste.

- **Facilitating market access:** Creating mechanisms to connect BSF project developers with carbon credit buyers, and streamlining national approval processes for carbon credit generation.
- **Awareness and capacity building:** Educating BSF entrepreneurs and local governments on the process of carbon credit generation, including eligibility criteria, monitoring requirements, and the benefits of participating in carbon markets.

3.5.3 Establishing clear guidelines for monitoring and verifying environmental benefits of BSF projects

Beyond methane reduction, comprehensive MRV guidelines should encompass a broader range of environmental benefits. These guidelines ensure transparency, accountability, and credibility:

- **Environmental KPIs:** Defining key environmental performance indicators (KPIs) such as waste diversion rates, nutrient recovery efficiency, energy consumption per unit of output, and water usage.
- **Monitoring protocols:** Establishing clear protocols for routine monitoring of operational parameters and environmental impacts at BSF facilities, including data collection frequency, responsibilities, and reporting formats.
- **Verification procedures:** Implementing independent verification processes (by third-party auditors) to ensure the accuracy and reliability of reported data and claimed environmental benefits, building trust among stakeholders and investors.

3.5.4 NDC integration: tracking metrics in national climate reports

For BSF to contribute meaningfully to national climate action, its impact must be formally integrated and tracked within national climate reports, NDCs:

- **Reporting frameworks:** Incorporating specific sections or categories within national GHG inventory reports and NDC progress updates to account for emission reductions achieved through BSF-based organic waste diversion.
- **Metric tracking:** Tracking key metrics such as "tonnes of organic waste diverted through BSF technology, "GHG emissions avoided (tCO_2e)," and "number of BSF facilities operational" in national climate reports.
- **Policy coherence:** Ensuring consistency between national waste management targets, agricultural policies, and climate action plans regarding BSF's role, promoting a harmonized approach to sustainable development.

By establishing robust MRV frameworks and effectively integrating BSF's climate benefits into national reporting, governments can fully leverage BSF technology as a significant contributor to achieving climate goals and fostering a sustainable circular economy.

3.6 Knowledge sharing & regional collaboration

To accelerate the adoption and optimize the impact of BSF technology across Africa, fostering robust knowledge sharing and regional collaboration is essential. Given the diverse contexts and experiences across the continent, a coordinated approach to disseminating best practices, developing common standards, and building capacity is crucial for maximizing the benefits of BSF for sustainable waste management and economic development.

3.6.1 Encouraging knowledge exchange and collaboration among African countries

National governments and regional bodies should actively promote platforms and mechanisms that facilitate the exchange of information, expertise, and lessons learned related to BSF implementation. This includes:

- **Regional forums and workshops:** Organizing regular conferences, workshops, and training events where BSF practitioners, researchers, policymakers, and entrepreneurs from different African countries can connect, share experiences, and build partnerships.
- **Online knowledge platforms:** Developing centralized online portals or databases that host case studies, technical guidelines, research findings, and contact information for BSF experts and projects across the continent.
- **South-South cooperation:** Facilitating direct knowledge transfer and technical assistance programs between countries with more advanced BSF sectors and those in earlier stages of adoption.
- **Study tours and exchange programs:** Supporting visits and exchanges between BSF facilities and research institutions in different African nations to promote practical learning and observation of best practices.

3.6.2 Regional BSF hubs: establishing centers of excellence

The establishment of regional centers of excellence can serve as focal points for research, training, and knowledge dissemination, accelerating BSF adoption and innovation. These hubs would:

- **Conduct applied research:** Focus on optimizing BSF rearing practices for regional conditions, evaluating locally available feedstocks, and developing appropriate technologies.
- **Provide training and capacity building:** Offer specialized training programs for BSF operators, entrepreneurs, and policymakers from across the region.
- **Host demonstration facilities:** Showcase successful BSF projects and technologies, serving as learning sites for practitioners and policymakers.
- **Facilitate networking:** Connect stakeholders, promote collaboration, and foster the development of regional BSF value chains.

3.6.3 Developing regional standards and markets for BSF products

Harmonized standards and market access are crucial for promoting trade and investment in the BSF sector across Africa. This involves:

- **Regional quality standards:** Collaborating to develop common standards for BSF-derived products (e.g., BSF meal, oil, frass) to ensure consistent quality, safety, and market acceptance across the continent.
- **Trade facilitation:** Reducing trade barriers and streamlining regulations for the import and export of BSF products within the region.
- **Market information and promotion:** Supporting the development of regional market intelligence and promotional campaigns to raise awareness of BSF products and connect suppliers with buyers.

3.6.4 NDC toolkit: creating a template for integrating BSF into national climate plans

To ensure BSF's contribution to climate action is fully recognized and leveraged, a standardized toolkit can assist African countries in integrating BSF into their national climate plans (NDCs):

- **MRV protocols:** Providing clear guidance on how to measure, report, and verify (MRV) the GHG emission reductions achieved through BSF-based waste diversion, aligning with international reporting standards.
- **Policy integration guidance:** Offering a template for incorporating BSF into national waste management policies, agricultural strategies, and climate action plans.
- **Case studies and best practices:** Showcasing examples of how other African countries have successfully integrated BSF into their NDCs and climate strategies.
- **Financing mechanisms:** Identifying potential sources of funding for BSF projects, including climate finance and carbon credit opportunities.

By prioritizing knowledge sharing, establishing regional hubs, harmonizing standards, and providing tools for policy integration, African nations can collectively unlock the transformative potential of BSF technology for sustainable waste management, economic development, and climate action.

Best-case examples of BSF implementation

4 Globally Recognized Best-Case Examples of BSF Implementation

This chapter highlights a selection of best practice BSF projects across the global South, with a particular focus on initiatives in Africa. The aim is to showcase diverse models of BSF implementation that have demonstrated success in addressing organic waste challenges, generating economic value, and contributing to environmental sustainability within their specific contexts. These case studies serve as invaluable learning examples, illustrating the practical application of BSF technology, key success factors, and transferable lessons for future projects. By examining these real-world examples, stakeholders can gain practical insights into operational models, technological choices, market linkages, and community engagement strategies that have proven effective in resource-constrained environments.

4.1 Bioconvision: A Best Practice BSF Project in Jinja, Uganda

This section details the journey and achievements of Bioconvision (Uganda) Ltd., showcasing its innovative approach to leveraging Black Soldier Fly technology for sustainable waste management and resource recovery in Uganda. Bioconvision exemplifies how scientific research can transition into commercial operation to address critical environmental challenges while simultaneously fostering economic growth and sustainable agricultural practices in the Global South.

Project Overview & Context

Bioconvision was founded in 2023, initially as a research initiative dedicated to designing and validating a scalable business model for waste-based insect farming. After successfully mastering insect reproduction and securing reliable waste streams, the company transitioned to commercial operation in 2025. Based in Jinja, Uganda, Bioconvision operates with a team of 12 employees, driven by the core goals of upcycling low-value biomass into high-value nutrition and fertilizer, thereby offering sustainable feed and fertilizer solutions to the market.

The BSF Operation: Waste to Value

Bioconvision operates as a fully integrated Black Soldier Fly (BSF) company, managing the entire value chain from waste sourcing and larvae breeding to waste treatment, product development, and sales. Their current operations are centered around a centralized treatment facility in Jinja. Building on their robust breeding capabilities, Bioconvision plans to expand by establishing additional treatment sites across the region.

The company utilizes a diverse range of organic waste materials as feedstock for its BSF larvae. These include food waste sourced from restaurants, schools, and marketplaces, as well as specific industrial by-products such as fish waste, brewers waste, and bakery waste. Uniquely, Bioconvision also incorporates water hyacinth, an invasive aquatic plant, into its waste streams. With the transition from research to scale, Bioconvision is currently increasing their daily waste treatment capacity from 1 tonne to 8 tonnes. This marks a major step toward gradually reaching the planned maximum capacity of 15 tonnes per day. Bioconvision strategically avoids seasonal waste streams to ensure consistent production and maintain consistent product quality in terms of nutritional value for both larvae and frass.

From these waste streams, Bioconvision primarily produces two BSF products: larvae for animal feed and frass for organic fertilizer. Their current production yields approximately 200 kg of fresh larvae (wet weight) and around 650 kg of insect frass (wet weight) per day. Upon full completion of the expansion, production is projected to scale up to 1,500 kg of fresh larvae and approximately 4,500 kg of insect frass daily. Their primary goal is to sell as much of their larvae as possible as fresh animal feed; any excess production is dried to extend its shelf life and is used for formulating compound feeds. Notably, Bioconvision does not produce insect meal or oil. Their insect frass undergoes a 4 to 6-week maturation process to stabilize the material and reduce biological activity before it is brought to market. While not currently generating carbon credits from reduced methane emissions, Bioconvision expresses strong interest in understanding the parameters and methodologies to explore this opportunity in the future.

Market Engagement & Value Creation

Bioconvision's target customers for their fresh larvae are predominantly poultry farmers, fish farmers, and piggery farmers, who benefit from the high-quality, affordable animal feed. The company also plans to expand into feed millers as a sales channel, integrating their larvae into commercial feed formulations, especially a floating pellet for the growing aquaculture industry. The insect frass, serving as an organic fertilizer, is primarily sold to coffee farmers and horticulture farmers, contributing to improved soil health and crop yields in these sectors.

Demonstrating Impact

Bioconvision's project delivers significant environmental and socio-economic benefits within its operational sphere:

- **Environmental Impact:** The project directly contributes to reducing landfill waste by diverting organic materials that would otherwise decompose and release harmful greenhouse gases. Beyond waste diversion, Bioconvision's unique approach helps in controlling the spread of invasive water hyacinth, transforming an ecological nuisance into a valuable resource. While specific quantification through a Product Carbon Footprint or Life Cycle Assessment is yet to be undertaken due to funding constraints, the company is confident that treating organic waste with BSF larvae, instead of sending it to open landfills, significantly lowers greenhouse gas emissions.
- **Socio-Economic Impact:** The project plays a vital role in creating local employment opportunities across its entire value chain, from waste collection and pre-processing to insect production and product sales. By providing affordable, high-quality animal feed and organic fertilizer, Bioconvision empowers farmers to reduce their production costs and enhance their crop and livestock yields. This, in turn, strengthens local food security and actively supports more sustainable, circular agricultural practices within the region.

Partnerships & Support Ecosystem

Bioconvision's development and success are underpinned by strategic partnerships. A key collaboration is with Makerere University and EAWAG from Switzerland, with whom they engage in scientific research and field trials to rigorously validate the effectiveness of their insect frass as an organic fertilizer. They also work closely with local government structures, primarily for navigating regulatory approvals and ensuring compliance. Furthermore, partnerships with other businesses, including agricultural companies and waste producers, are crucial for securing a consistent and reliable supply of feedstock for their operations. The overarching goal of these diverse partnerships is to facilitate knowledge transfer, guarantee access to essential raw materials, ensure regulatory adherence, and strengthen market acceptance for their innovative products.

In terms of external support, Bioconvision received an initial research grant that served as a critical kick-start for the project. This was followed by a second grant specifically to support their transition into commercial production. Additionally, the company secured a concessional loan, which was instrumental in completing construction and financing the initial stages of their commercial operations.

Key Success Factors & Policy Insights

Bioconvision identifies a powerful combination of factors driving its success: a strong local team with excellent networks and a deep understanding of the market, coupled with international scientific expertise and technical know-how. This blend allows them to operate effectively on the ground while simultaneously applying globally recognized best practices in insect farming.

Despite their achievements, Bioconvision faces key challenges. While they have successfully secured reliable waste streams and consistent production of young larvae, their current primary challenge lies in preparing the market for their larvae product. The biggest obstacle is overcoming the perception of insect larvae as a cheap, low-quality source of animal nutrition, and instead establishing it as a superior, healthy, sustainable, and locally produced alternative. To address this, they are actively developing clear feeding regimes for integrating live larvae into livestock diets, alongside application guidelines for frass across different crops and plants. Regulatory compliance also presents a challenge; while they appreciate regulations for safety and environmental protection, requirements such as conducting an Environmental and Social Impact Assessment (ESIA) impose significant financial burdens, particularly during early business stages.

From their perspective, the Ugandan government generally welcomes BSF farming as an emerging technology with potential for waste management. However, Bioconvision wishes that national/regional policymakers would provide more concrete government support in the form of compensation or incentives for waste handlers, given that they actively remove and treat waste. Their advice to others building a BSF business is to anticipate significant baseline costs associated with bringing a marketable product to market. This includes securing product approval from the Ministry of Agriculture, obtaining quality certification through bodies like UNBS, and acquiring necessary waste handling licenses. They emphasize that while these steps are essential, they demand considerable time, resources, and a robust business case to cover the associated expenses.

Future Outlook

Bioconvision has clear plans for future growth and expansion. They aim to scale their operations over time, indicating a commitment to continued development and an increased impact on sustainable waste management and agricultural practices in the region.

Selection of Photos

Figure 4-1: Bioconvision BSF plant - BSF plant - Rearing of BSF larvae

Source: Bioconvision

Figure 4-2: Bioconvision BSF plant - BSF "Love Cage" for the production of BSF eggs

Source: Bioconvision

4.2 Chanzi: A Best Practice BSF Project in Tanzania & Kenya

This section details the journey and achievements of Chanzi, a pioneering company leveraging Black Soldier Fly (BSF) technology for sustainable waste management and resource recovery across East Africa. Chanzi stands out as a compelling example of how innovative solutions can address critical environmental challenges while simultaneously fostering economic growth and social development in the Global South.

Project Overview & Context

Founded in 2019 by Sune Mushendwa (COO) and Andrew Wallace (CEO), Chanzi was established with a clear mission: to tackle East Africa's escalating organic waste crisis and reduce the region's reliance on environmentally unsustainable animal feed ingredients. The company developed a circular solution that harnesses Black Soldier Fly larvae to efficiently process organic waste, transforming it into high-value, protein-rich animal feed and nutrient-dense organic fertilizer. Currently, Chanzi operates in four cities across Tanzania and Kenya, employing 131 full-time staff and supporting an additional 92 indirect jobs. Their overarching goal is to reduce organic waste, provide sustainable and affordable animal feed and organic fertilizer, create green jobs, and significantly mitigate landfill methane emissions.

The BSF Operation: Waste to Value

Chanzi's operational model is characterized by its decentralized modular BSF farming systems, specifically designed and tailored for African conditions using local designs and equipment. This approach allows for adaptability and cost-effectiveness. The company primarily utilizes a diverse range of organic waste, including post-consumer household food waste, industrial food waste, farm waste, and market waste. Across its facilities in four cities, Chanzi collectively processes an impressive 75 metric tonnes of organic waste per day, with individual facilities handling between 18 to 52 tonnes daily.

From this organic waste, Chanzi produces two primary BSF products: dried BSF larvae, used as animal feed, and frass, which is processed into organic fertilizer. Additionally, they produce an activated frass and biochar blend. Currently, the company produces and sells between 1–2 metric tonnes of dried BSF larvae and 2–4 metric tonnes of frass fertilizer per day. The larvae undergo a quality-controlled drying process before packaging for sale, while the frass is uniquely activated during the production cycle using ground biochar derived from pyrolysis. Importantly, Chanzi is actively pursuing carbon credits using Verra’s methodology (landfill avoidance ACM 0022), recognizing the significant methane emission reductions achieved through their waste diversion efforts.

Market Engagement & Value Creation

The high-value BSF products generated by Chanzi address a critical demand within the agricultural sector. Their primary buyers include poultry, pig, and fish farmers, as well as feed millers and arable farmers across East Africa. Chanzi secures its market linkages through strategic off-take agreements with some of the region’s largest livestock producers, such as Kenchic, Interchic, and Victory Farms, ensuring consistent demand for their protein products.

The company is also investing in vertical integration by establishing its own feed mill, further cementing its position in the animal feed value chain.

Demonstrating Impact

Chanzi's operations deliver substantial environmental and socio-economic benefits:

- **Environmental Impact:** Through BSF and Biochar, Chanzi have the ability to divert all organic waste streams from landfills, and have directly prevented the emission of over 350 tonnes of methane so far. This waste valorization also contributes to avoiding overfishing (by providing an alternative to fishmeal) and deforestation (by reducing reliance on soy meal).
- **Socio-Economic Impact:** Chanzi has created 131 direct jobs and supports thousands of indirect livelihoods, including those of waste collectors. By providing an affordable and sustainable protein source, the company helps farmers reduce protein costs in animal feed by an average of 37.5%, thereby enhancing their profitability. The use of BSF frass also leads to increased crop yields for arable farmers. Furthermore, the project offers dignified employment opportunities for former waste pickers, contributing to social upliftment.

Partnerships & Support Ecosystem

Chanzi's success is deeply intertwined with its robust network of strategic partnerships across its value chain. On the input side, collaborations with local waste management companies like Okota in Tanzania and Taka Taka Solutions in Kenya are central to securing a consistent and segregated waste supply. These partnerships not only ensure feedstock for Chanzi but also bolster local waste management infrastructure and create employment in waste collection and sorting. A notable example is Chanzi's consortium work with Okota and Taka Taka Solutions for projects with companies like AB InBev, initiated through the 100+ Accelerator program. This partnership has since expanded significantly through P4G (Partnering for Green Growth), enabling Chanzi to grow in Tanzania and enter the Kenyan market, working with two multinational corporations. On the output side, off-take agreements with major livestock producers ensure product sales. The company is also in negotiations with municipal governments to privatize city landfills, aiming to extend their lifespan by diverting vast amounts of waste, valorizing it, and creating thousands more green jobs. Chanzi has also received crucial support from donor organizations including WWF, BPF, and the Gates Foundation.

Key Success Factors & Policy Insights

Several factors have been instrumental in Chanzi's success:

- **Context-Appropriate Innovation:** Unlike many ventures that attempt to directly replicate European BSF models, Chanzi designed low-cost, modular production systems specifically tailored for East Africa. Their model strategically leverages local materials and labor, minimizing dependence on expensive, high-tech imports, which significantly reduces both capital and operational expenditures.
- **Integrated Waste Management:** By establishing Okota, their dedicated waste management arm, Chanzi ensured a vertically integrated waste supply system. This

guarantees a steady and reliable stream of organic waste, a critical input for BSF production, while also enabling the processing of multiple inorganic waste streams for diversified revenue and enhanced environmental impact.

- **Strong Market Demand and Product Relevance:** Their insect-based protein and organic fertilizer directly address critical issues in the agricultural sector: the high cost and unsustainability of traditional feed and fertilizers. The low-cost model allows them to achieve a price point below alternatives like fishmeal, resulting in full daily sell-through with minimal marketing efforts, underscoring the strong market relevance and value of their products.

However, Chanzi has also faced significant challenges, including operational complexity across multiple decentralized facilities, ensuring standardized procedures, and maintaining consistent product quality in varied local contexts. A major obstacle was initially the lack of a reliable and consistent waste supply, which directly led to the establishment of Okota. Navigating complex regulatory environments and delays in obtaining permits for waste handling and biochar production also caused operational delays. Access to affordable capital for expansion remains a hurdle due to the nascent nature of the BSF sector in Africa.

Regarding the regulatory environment, Chanzi notes that while waste management regulations in Kenya and Tanzania (such as Kenya's Sustainable Waste Management Act and environmental guidelines under NEMC in Tanzania) broadly support waste segregation and recycling, their implementation and enforcement often remain inconsistent or non-existent. This regulatory gap can hinder operations, particularly when attempting to expand into new municipalities. In essence, Chanzi states they often operate "in spite of regulation, not because of it." From their perspective, the ideal scenario would involve minimal government intervention or policy. While acknowledging that financial incentives, tax breaks, or subsidies for circular economy initiatives could accelerate sector growth, they view the idea of governments offering such support for sustainable businesses as "wishful thinking," suggesting a focus on pragmatic business solutions over policy advocacy.

For anyone venturing into BSF or circular waste management in Africa, Chanzi's key advice is to localize your approach. They strongly recommend against importing models not designed for local socioeconomic realities. Building early partnerships, especially with waste producers/aggregators and, if applicable, local governments, is crucial. Their advice includes starting small, proving the model, gaining traction and scaling modularly, while prioritizing impact alongside core financial sustainability. Most importantly, they emphasize investing in people—the team, the community, and suppliers—as much as in technology.

Future Outlook

Chanzi is firmly committed to significant expansion. Having already extended operations to four East African cities, the company has clear plans for another 12, with an ambitious target of operating 47 facilities across Sub-Saharan Africa within the next decade. Their modular model enables quick and affordable scaling, and they are currently developing an ERP system to efficiently manage their growing network of remote sites. With increasing demand for sustainable feed and fertilizer, coupled with the imperative for climate mitigation, Chanzi views expansion as both a significant opportunity and a necessity.

Selection of Photos

Figure 4-3: Chanzi BSF plant - BSF "Love Cage" for the production of BSF eggs

Source: Chanzi

Figure 4-4: Chanzi BSF plant - Composting of BSF frass for further use as organic fertilizer

Source: Chanzi

Figure 4-5: Chanzi BSF plant - Rearing of BSF larvae

Source: Chanzi

4.3 Alpha Protein Feeds Ltd: A Best Practice BSF Project in Kiambu County, Kenya

This section delves into the operations and impact of Alpha Protein Feeds Ltd., an emerging leader in Black Soldier Fly (BSF) technology in Kenya. The company exemplifies a highly localized approach to organic waste management and the production of sustainable animal feed, demonstrating how distributed solutions can effectively address pressing environmental and economic challenges within defined geographical proximities.

Project Overview & Context

Alpha Protein Feeds Ltd. was established in 2024 in Gathiga Road, Kiambu County, Kenya, by its Founder & CEO. The company's core mission is to manage municipal and commercial waste streams within a defined local proximity, aiming to reduce emissions for businesses and municipalities. Concurrently, they manufacture and distribute animal feeds within these same vicinities. This highly localized model is rooted in the belief that while waste management is a global issue, effective solutions must be addressed at a local level.

The company's genesis stemmed from observing that early entrants into the BSF segment often incurred high logistics costs due to the transportation of waste over long distances. Alpha Protein Feeds sought to optimize waste collection and processing by focusing on proximity. They began by partnering with corporate entities, primarily malls and restaurants, before expanding to collaborate with Kiambu County to address their significant market waste problem, which averages an estimated 30 tonnes per market per week. Currently, Alpha Protein Feeds processes waste from two markets in Kiambu and is in the process of onboarding a third. The company currently employs 9 individuals.

The BSF Operation: Waste to Value

Alpha Protein Feeds operates a decentralized, closed-loop BSF system. This integrated model manages waste processing, breeding, incubation, and product processing all within its localized framework. Their approach is built around the "pit method," combined with specially designed polytunnels and sophisticated climate Internet of Things (IoT) systems powered by Flybox® technology. This setup is designed to maintain best-in-class climate conditions for BSF rearing within the African context. A second site, based on this identical modular model, is already under development.

The company primarily utilizes market waste, which forms the bulk of their feedstock. They also integrate commercial waste streams from partners such as malls and restaurants. Alpha Protein Feeds currently processes between 20-25 tonnes of organic waste per week. However, they possess a significantly larger installed capacity of between 70-80 tonnes per week, indicating considerable room for growth. While market waste can exhibit seasonal variations in availability, the company balances this by incorporating more homogenous waste streams from commercial partners, such as waste from avocado oil processors, ensuring a more consistent supply.

The primary BSF products manufactured are dried larvae for animal feed and frass for fertilizer. Currently, Alpha Protein Feeds sells approximately 1 ton of dried larvae per week as they continue to scale their operations. Larvae are processed using a commercial dryer located on-site. The company has expressed interest in carbon credit programs through the Kenya BSF association but has not yet monetized its emission savings, indicating a future potential revenue stream from their waste diversion efforts.

Market Engagement & Value Creation

Alpha Protein Feeds' main customers are livestock farmers who prefer to blend their own animal feeds, valuing the high crude protein (CP) content and lower prices of BSF-derived feed compared to conventional alternatives. They also cater to local farmers, selling smaller quantities of their products directly. The company has received positive feedback from their poultry feed customers regarding both the quality and affordability of their product. Beyond animal feed, they also produce custom fertilizer blends that incorporate chitin, aiming to provide organic pest resistance to support local agricultural practices.

Demonstrating Impact

Alpha Protein Feeds delivers tangible environmental and socio-economic benefits within its operational areas:

- **Environmental Impact:** By diverting significant quantities of organic waste, the project directly reduces the volume of waste sent to landfills. This is particularly impactful as organic waste in Kiambu County would typically travel approximately 50 kilometers to a landfill. By intercepting this waste locally, Alpha Protein Feeds not only mitigates methane emissions from landfill decomposition but also significantly reduces fuel emissions and transportation costs for municipalities associated with waste hauling.
- **Socio-Economic Impact:** The company directly contributes to job creation, currently employing 9 individuals, with plans to triple staffing by Q1 2026 with the opening of their second location. Their affordable BSF feed offers a cost-effective alternative for local livestock farmers, improving their margins. Furthermore, the specialized fertilizer blends contribute to more sustainable farming practices and potentially enhanced crop health.

Partnerships & Support Ecosystem

Alpha Protein Feeds has forged key partnerships to support its localized operational model. A crucial collaboration is with Kiambu County, where they work directly with municipalities to support their waste management efforts. This partnership includes the county providing logistics support free of charge, demonstrating a tangible commitment to the collaboration. The company also partners with Flybox®, a prominent insect technology company. Flybox® provides essential expertise in breeding and nutrition, along with specialized hardware, software, and tailored climate control solutions specifically designed for insect farming in the African context, ensuring best-in-class operational conditions.

Despite these vital operational partnerships, Alpha Protein Feeds has not yet received direct government funding or any grant funding. They are, however, actively engaged in conversations with various entities to secure such assistance for future growth.

Key Success Factors & Policy Insights

Alpha Protein Feeds attributes its success to several critical factors:

- **Cost-Effective Infrastructure & IoT Solutions:** Leveraging lower-cost infrastructure combined with advanced IoT solutions from Flybox® has enabled efficient and optimized operations.
- **Strategic Municipal Partnerships:** Collaboration with Kiambu County has been instrumental, providing crucial support in waste acquisition and logistics.
- **Specialized Machinery:** The strategic import of specialized machinery from China has contributed to their operational efficiency.

The company has faced its share of challenges, including the inherent time-consuming and bureaucratic nature of working with government entities, complexities in waste acquisition logistics, and the current lack of a customized Enterprise Resource Planning (ERP) system for efficient system management.

Regarding the regulatory landscape, Kenya's Sustainable Waste Management Act of 2023 mandates the streaming of waste into organic and inorganic fractions, which theoretically assists Alpha Protein Feeds by eliminating some sorting challenges. However, the company notes that the enforcement of this act remains uneven, making it an unreliable factor in their daily operations. While the UN supports the Council of Governors with sustainability initiatives that include programs relevant to BSF, the practical impact on Alpha Protein Feeds' day-to-day operations is limited by enforcement consistency.

When asked about desired policy changes, Alpha Protein Feeds directly wishes for more consistent enforcement of the waste management act. They believe that stronger enforcement would significantly facilitate their ability to enroll households and neighborhoods more effectively, as these currently require extensive sorting efforts on their part. Their advice to other aspiring BSF entrepreneurs underscores the challenging unit economics of this business, emphasizing that the costs of waste acquisition, including logistics and labor, must be rigorously controlled to ensure healthy margins.

Future Outlook

Alpha Protein Feeds is in a phase of active expansion. They are currently planning to open two more locations by Q1 2026, underscoring their commitment to scaling their successful localized model across additional areas. This expansion reflects their belief in the viability and necessity of decentralized BSF solutions for addressing waste and feed challenges.

Selection of Photos

Figure 4-6: Alpha Protein Feeds BSF Plant - "Love Cages" for BSF egg production

Source: Alpha Protein Feeds

Figure 4-7: Alpha Protein Feeds BSF Plant - Trays for BSF rearing

Source: Alpha Protein Feeds

4.4 GrubFeeds (AKUPARA VENTURES): A Pioneering BSF Project in Kandal and Phnom Penh, Cambodia

This section highlights GrubFeeds (AKUPARA VENTURES), a leading Black Soldier Fly (BSF) project in Cambodia. The company exemplifies an innovative, decentralized approach to organic waste management, producing sustainable animal feed and biofuel, and effectively addressing environmental and economic challenges.

Project Overview & Context

GrubFeeds began BSF operations in 2023 in Kandal and Phnom Penh, Cambodia. Founded by its CEO, the core mission is to produce animal feed and biofuel. Initially focused on reducing feed costs with insect meal, the project evolved into a decentralized contract farming model. Recognizing the potential of BSF oil, GrubFeeds expanded into Sustainable Aviation Fuel (SAF), securing strategic partnerships with major oil and gas players. The company employs fewer than 10 individuals. Find more at Facebook and LinkedIn.

The BSF Operation: Waste to Value

GrubFeeds uses a hybrid BSF model combining decentralized rearing with centralized processing, supported by IoT and AI technologies and a Production-as-a-Service (PaaS) business model. Local partners rear larvae using bio-waste, while GrubFeeds handles centralized processing, leveraging data for efficiency.

The company primarily utilizes market waste (fruits and vegetables), with pilot trials for household waste and agri-residues. They currently process 500-1,000 kg/day, with plans to expand to 100 tonnes/day. Waste availability varies seasonally.

GrubFeeds produces fresh & dried BSF larvae (for poultry, aquaculture, pigs), defatted BSF meal, BSF oil (for pet food, biofuel), and BSF frass (fertilizer). Current focus is on 1-2 MT/month of fresh larvae for local farmers. They've modeled 180,000 carbon credits under Verra's VCS. Main buyers are poultry/pig farmers, aquaculture, biofuel developers, and organic farmers.

Market Engagement & Value Creation

GrubFeeds' main customers are livestock farmers, aquaculture, biofuel developers, and organic farmers. Their products offer high-quality, sustainable, cost-effective alternatives for feed and fertilizer, while BSF oil opens diverse markets.

Demonstrating Impact

GrubFeeds delivers significant environmental and socio-economic benefits:

- **Environmental Impact:** Diverts organic waste from landfills (reducing methane), replaces unsustainable feed ingredients (fishmeal/fish oil), and produces frass for soil health/regenerative agriculture.
- **Socio-Economic Impact:** Creates rural jobs, fosters entrepreneurship (women and youth), provides affordable, high-quality feed/fertilizer to local farmers, and generates new income streams for cooperatives/waste handlers.

Partnerships & Support Ecosystem

Key partners include local agricultural cooperatives (waste sourcing), universities/R&D bodies (trials), NGOs (non-dilutive grants), and tech providers. A successful grantee of the USAID Feed the Future Programme in 2024, GrubFeeds now collaborates with local authorities on waste and fertilizer pilots, though these require significant investment.

Key Success Factors & Policy Insights

- **Success factors:** bio-waste availability via decentralized model, low-cost local labor, AI/IoT integration, KISS principles, and UN SDG alignment.
- **Challenges:** inconsistent waste supply/quality, limited product awareness, infrastructure/skill gaps, regulatory ambiguity, and lack of patient capital.

GrubFeeds notes fragmented regulations on organic waste, feed safety, and fertilizer. They advocate for policy makers to approve insect-based protein for animal feed, incentivize waste-based innovations, and harmonize organic fertilizer certifications. Advice to others: "Think Big, Start Small," engage local stakeholders early, and prioritize consistent waste sourcing, data-driven analysis, operational quality, lean models, and early tech adoption.

Future Outlook

GrubFeeds aims to be a leading Southeast Asian insect protein producer with a "doubly sustainable" (environmental and financial) business model. They seek patient capital for regional expansion across Southeast Asia, and explore partnerships in South Asia, MENA, and the US for animal feed/SAF, and Africa for knowledge transfer. Their goal is a facility upcycling 100 tonnes/day of bio-waste to produce 100 tonnes/month BSF meal and 30 tonnes/month BSF oil, requiring USD 1-1.2 million in Cambodia/Thailand (or USD 6.5 million in US/Canada) in countries like the US/Canada.

4.5 Living Soils: A Best Practice BSF Project in Cote d'Ivoire

This section highlights the innovative and community-focused approach of Living Soils, an organization dedicated to regenerating soils and empowering communities through Black Soldier Fly (BSF) technology in Cote d'Ivoire. Living Soils exemplifies a decentralized, low-tech bioeconomy model that integrates waste management with sustainable agriculture, offering valuable lessons for policymakers and practitioners in the Global South.

Project Overview & Context

Living Soils was formally established in 2024 as an association, though its roots trace back to 2020 when co-founder and project manager Arthur de Dinechin began pioneering BSF farming in Côte d'Ivoire through his initial venture, BioAni. This earlier initiative focused on converting organic waste into valuable agricultural inputs—organic fertilizer and insect-based protein—via the BSF life cycle. Over four years of on-the-ground experience revealed the harsh realities of waste mismanagement, soil degradation, and rising input costs faced by West African farming communities. Simultaneously, it underscored the immense potential of decentralized, low-tech bioeconomy solutions to restore soil health, empower farmers, and close crucial nutrient loops.

Following a transition out of BioAni, Arthur founded the Living Soils Association with a sharper, more integrated focus: combining BSF farming with holistic soil regeneration, cooperative empowerment, and circular resource management. Their first flagship site was established in Grand-Bassam, Côte d'Ivoire, with support from the FAO and UN Global Pulse. This quickly evolved into a growing network of decentralized micro-farms across the country, with 10 employees. The association launched its first women's cooperative program in 2024, training local women to become "insectpreneurs" and lead their own sustainable production units. Living Soils views itself as a regional leader in insect-based regenerative farming in West Africa, driven by its core mission to restore living soils and empower communities from the ground up. In a unique initiative planned for 2027, Living Soils will embark on the "Living Soils Expedition," a three-year global sailing journey to document and connect regenerative soil solutions across 30 tropical countries, aiming to bring visibility, scientific understanding, and solidarity to the global soil regeneration movement.

The BSF Operation: Waste to Value

Living Soils champions a low-tech approach to BSF technology, coupled with a focus on genetic selection to optimize their insects' performance. Their preferred operational model is decentralized, which they believe empowers farmers while simultaneously reducing production risks. The primary feedstock utilized across their operations is market waste.

The waste processing capacity varies between their centralized and decentralized models. A decentralized farm can process 720 kg of waste per day, while their centralized farm handles between 240 to 350 kg daily. Living Soils indicates that this volume is either below or equivalent to their current available waste management capacity, emphasizing their belief in operating multiple small, agile farms rather than a single large one. They acknowledge that waste availability can vary depending on farm location; farms further from big cities experience more fluctuations due to less access to consistent waste streams and greater reliance on seasonal harvesting.

Living Soils produces a variety of BSF products. These include fresh and dried larvae, solid and liquid frass (biostimulant), and exuvia powder for plant and soil protection. The quantities produced and sold differ between their central nursery and the decentralized farms. In the nursery, 20% of larvae are retained for their own fish and chicken, while 80% of larvae (approximately 20 to 50 kg per day per farm) are sold. For frass, 10% is kept for their own plantations, 30% is liquefied, and 60% is sold as a solid amendment, though they note that selling solid frass can be challenging as it is a relatively new product in the market. In the decentralized farms, 100% of the larvae produced are fed directly to chickens, pigs, or fish, contributing to on-farm feed security. For frass, 10% is kept for cultivation, and 90% is sold to local farmers. Fresh larvae constitute 80% of their larval output, with 20% being dried. Frass undergoes a two-week maturation process as compost, with a minority being liquefied to create a biostimulant. Living Soils has explored carbon credit programs related to methane emission reduction but has not yet pursued them, finding the economic benefits currently too limited. Their primary buyers for larvae and frass are poultry farmers, fish farms, and local farmers.

Market Engagement & Value Creation

Living Soils strategically engages local markets by providing diverse BSF-derived products tailored to agricultural needs. Their fresh and dried larvae directly serve poultry farmers, fish farms, and local farmers as a sustainable and high-quality feed alternative. The solid frass, primarily used as an organic amendment, targets local farmers, although market adoption for this newer product is a noted challenge. Furthermore, the liquefied frass, functioning as a biostimulant, and exuvia powder for plant protection, aim to offer natural alternatives to chemical inputs, supporting a shift towards agroecological practices. The integration of BSF products into their own small-scale poultry and vegetable production also serves as a direct demonstration of the value chain.

Demonstrating Impact

Living Soils contributes significantly to both environmental sustainability and socio-economic development:

- **Environmental Impact:** The project plays a crucial role in reducing waste in cities by upcycling organic waste. A central tenet of their work is regenerating soils, providing a natural alternative to chemical fertilizers and pesticides. By producing insect protein, they also help reduce reliance on fishmeal and other conventional protein sources. Their decentralized model inherently reduces transportation costs and associated emissions by establishing farms close to farmers' needs. Furthermore, by collecting waste and using frass to regenerate soils, the project contributes to carbon capture.
- **Socio-Economic Impact:** Living Soils directly creates local jobs, particularly for low-educated individuals, contributing to inclusive economic growth. Their small, low-tech, and local farms help to reduce production costs for farmers. This translates

into an increase in farmers' revenue, providing affordable products and often leading to more bountiful harvests. The project also facilitates the diversification of income streams for communities. By reducing reliance on pesticides, it contributes to improved human and animal health.

Partnerships & Support Ecosystem

Living Soils actively cultivates a robust network of partnerships to achieve its goals. They collaborate with local NGOs on common projects and support initiatives. Significant financial support has been received from international organizations, including the FAO, PAM, Nestlé, ETG Beyond Beans, and ACTED. For knowledge transfer and scientific validation, they partner with universities and research institutions. While they have strong support from these international and research entities, Living Soils indicates that they have not received direct governmental support from Cote d'Ivoire.

Key Success Factors & Policy Insights

Living Soils attributes its success to a combination of factors:

- Their decentralized model, which empowers farmers and mitigates production risks.
- The strategic reduction of starting costs through a deliberate low-tech approach, making the projects more accessible and financially sustainable.
- Over four years of intensive field experience and learning from mistakes, which has refined their operational and strategic approach.

Despite these successes, Living Soils faces significant challenges. They find it difficult to secure funding without relinquishing a large share of the company, and suitable "kickstart" funds are often either too large, too small, or too slow to access. Another major obstacle has been persuading farmers, who are accustomed to chemical inputs, to adopt new practices, leading to initial difficulties in finding buyers for their products. They also note a lack of readily available, good engineering solutions for sustainable machinery tailored to their needs.

Regarding regulatory frameworks, Living Soils states that no specific waste management regulations are currently in place that directly impact their project, either supportively or hamperingly. When asked what national/regional policymakers could have done differently, Living Soils expressed a clear desire for direct support in the form of grants and funding. They also seek assistance with waste collection, which is currently too expensive for them to manage comprehensively. Furthermore, they emphasize a need for support without associated "hidden costs" and wish to be included in existing sustainable projects.

Their advice to others looking to establish BSF ventures is to start small. They recommend initially using BSF products to produce chickens, chicken eggs, and vegetables on a small scale rather than immediately trying to sell the BSF products themselves. A key operational lesson shared is to only scale up when consistent egg production (e.g., 15 days straight with over 80g/day) is achieved, even if it means discarding most eggs initially. They stress the importance of consistently tracking actions to avoid repeating mistakes and maintaining a clean farm environment.

Future Outlook

Living Soils is in an active phase of expansion. By December 2024, they had 1 farm, which grew to 3 farms by June 2025, and they have already secured financing for 9 farms by November 2025. Their ambitious plans include establishing 50 decentralized farms in Côte d'Ivoire by 2028, with expansion into Senegal and other countries planned for in 2026. This ongoing growth underscores their commitment to scaling their impact across West Africa and beyond.

Selection of Photos

Figure 4-8: Living Soils BSF plant - "Love Cages" for BSF egg production

Source: Living Soils

Figure 4-9: Living Soil BSF plant - Shed for BSF rearing

Source: Living Soils

4.6 International Institute of Tropical Agriculture (IITA) - RUNRES Project: A Best Practice BSF Project in Rwanda

This section details the journey and achievements of the International Institute of Tropical Agriculture (IITA)'s Rural-Urban Nexus (RUNRES) project, a pioneering initiative dedicated to developing and scaling innovative solutions for resilient and sustainable urban food systems, leveraging circular economy principles including Black Soldier Fly (BSF) technology. RUNRES stands out as a compelling example of how integrated solutions can address critical environmental challenges while simultaneously fostering economic growth and social development in the Global South.

Project Overview & Context

The Rural-Urban Nexus (RUNRES) project, spearheaded by the International Institute of Tropical Agriculture (IITA), with an Agribusiness Specialist as Project Coordinator in Rwanda, officially started its Phase I from 2019 to 2023, with Phase II currently running from 2024 to 2026. The project's overarching goal is "Establishing a Nutrient Loop to Improve City Region Food System Resilience." Specifically, RUNRES aims to co-design, test, implement, and scale safe, cost-efficient, and socially acceptable innovations that valorize urban and rural waste resources and enhance food value chains, thereby improving the resilience of city-region food systems.

The RUNRES initiative is an eight-year commitment to developing and scaling innovative solutions for resilient urban food systems by promoting circular economies. Working with transdisciplinary innovation platforms in Arba Minch, Ethiopia; Bukavu, DRC; Kamonyi, Rwanda; and Msunduzi, South Africa, RUNRES innovations focus not only on improved solid waste management but also on improved sanitation and waste management, which enhance environmental and human health. These efforts produce valuable soil inputs like compost, co-compost, vermi-compost, and BSFL frass, offering sustainable alternatives for agricultural productivity and household livelihoods.

In Rwanda, the RUNRES project began in June 2019 after an agreement was signed between IITA and ETH Zurich (ETH). Phase I focused on planning, context studies, establishing innovation platforms, testing biocircular innovations, and disseminating research. Phase II aims to co-design, test, and upscale these innovations, prioritizing the identification and development of innovation leaders from traditionally marginalized communities, aligning with SDC's mandate of inclusive development. The team also engages political leaders, private investors, and public sector agencies to facilitate expansion. Currently, for Phase II in Rwanda, RUNRES collaborates with six entrepreneurs: three scaling High-Quality Cassava Peel Flour (HQCPF) and three scaling Black Soldier Fly Larvae (BSFL) innovations. The project currently has 3 project staff (RUNRES Rwanda Project Team). More information can be found at the webpage of the "RUNRES – Establish a circular economy for resilient city region food systems" project webpage under: https://runres.ethz.ch/

The BSF Operation: Waste to Value

The BSF technology currently used by RUNRES partners is primarily centralized, implemented by private companies collaborating with the project. However, some partners are working to transition to a decentralized approach by engaging local communities as outgrowers or suppliers of organic household waste.

The waste utilized primarily includes food waste from breweries, processing factories, households, and markets. Currently, one active partner processes approximately 25 metric tonnes of waste per month. Two other partners are in the setup phase to begin scaling up. The volume of processed waste exceeds the current waste management capacity significantly. There are no significant variations in the availability of the types of waste utilized in BSF production over time.

From this organic waste, the RUNRES project supports the production of three primary BSF products: Fresh Black Soldier Fly Larvae (BSFL) for feed, Dried BSFL for feed, and frass for fertilizer. Data on the quantity of products produced/sold for the previous period is not yet compiled. The larvae are processed into fresh/wet larvae, dried, and ground into meal. The frass can be sold directly or allowed to decompose into fine compost. Carbon credits generated from reduced methane emissions are not currently measured.

The primary buyers of these BSF products include poultry farmers, fish farmers, local farmers, cooperatives involved in agriculture, and other BSF producers who wish to buy eggs. Additionally, the project includes other waste processing innovations, such as converting cassava peels into High-Quality Cassava Peel Flour (HQCPF), a carbohydrate-rich animal feed.

Market Engagement & Value Creation

The high-value BSF products generated by RUNRES's partners address critical demand within the agricultural sector. Their primary buyers include poultry farmers, fish farmers, local farmers, and cooperatives. The project also supplies other BSF producers seeking eggs. By providing diverse BSF products, RUNRES contributes to sustainable protein sources and organic fertilizers, supporting various agricultural needs in Rwanda.

Demonstrating Impact

The RUNRES project's operations deliver substantial environmental and socio-economic benefits:

- **Environmental Impact:** The innovative technologies reduce human health and environmental problems, primarily by reducing landfill wastes. Improved waste management strategies mitigate public health burden and environmental/social challenges caused by inadequate sanitation and waste removal. The project also improves soil health and fertility in adjacent agricultural zones.
- **Socio-Economic Impact:** The innovative technologies strengthen small-scale processing and value addition, providing new avenues of economic development for poor and disadvantaged people. Farmers, especially women and young people, benefit from enhanced economic opportunities due to the jobs that are created.

Partnerships & Support Ecosystem

The RUNRES project's success is deeply intertwined with its robust network of strategic partnerships. Main partners include local government, national research institutions such as the Rwanda Agriculture and Animal Resources Development Board (RAB), multistakeholder platforms focusing on circular food systems and regenerative/conservation agriculture in Rwanda, and potential investors such as financial institutions and grant donors. The primary goals of these partnerships are knowledge sharing, financing, and lobbying.

The project has received significant support from international donor organizations; the main donor for the project is the Swiss Agency for Development and Cooperation (SDC).

Key Success Factors & Policy Insights

Several factors have been instrumental in the RUNRES project's success:

- Piloting of innovations through co-designing and co-testing before scale-up.
- Strong stakeholder collaboration and engagement.
- Technical and business support to partners.

However, the project currently faces significant challenges, including infrastructure challenges, limited operational capacity, funding and resource constraints (smaller startups struggling to scale due to insufficient funding and lack of necessary equipment), and policy engagement gaps.

Regarding the regulatory environment, the Rwandan government's Strategic Plan for Agriculture Transformation (PSTA-5) is a supportive regulation, as it champions modernization and climate-resilient agri-food systems, emphasizing circular economy principles including safe recycling of organic waste and alternative animal feeds, which aligns well with RUNRES innovations like HQCP and BSFL. RUNRES has also prepared policy briefs and advocacy documents summarizing recommendations to support food and human waste recycling, aiming to positively influence regulations. However, the project notes that limited active policy engagement during the implementation of these policies means regulatory framework support is still evolving and not fully established to ease scaling.

When asked about desired policy changes, the project wishes national/regional policy makers had done differently:

- **Faster policy integration:** More proactive and timely adoption of policies supporting circular economy innovations, including officially recognizing and incentivizing alternative feed and fertilizer products (HQCP, BSFL).
- **Improved infrastructure investment:** Especially for rural enterprises, which would significantly remove operational bottlenecks.
- **More financial support frameworks:** Tailored agricultural finance products or grants to facilitate access to capital for youth-led and small enterprises would accelerate scaling.

- **Stronger multi-sectoral coordination**: Enhanced collaboration between agriculture, health, and environment ministries to streamline regulation and promote integrated waste management solutions.

For anyone venturing into BSF or circular waste management, the advice is to prioritize early and frequent stakeholder engagement. They also recommend focusing on inclusive employment models that empower women and youth, which strengthens social buy-in and sustainability. Investing in infrastructure planning and building partnerships with technical experts to ensure smooth operational scale-up is crucial. Finally, they advise remaining adaptable and patient with regulatory processes, while actively advocating for enabling policies.

Future Outlook

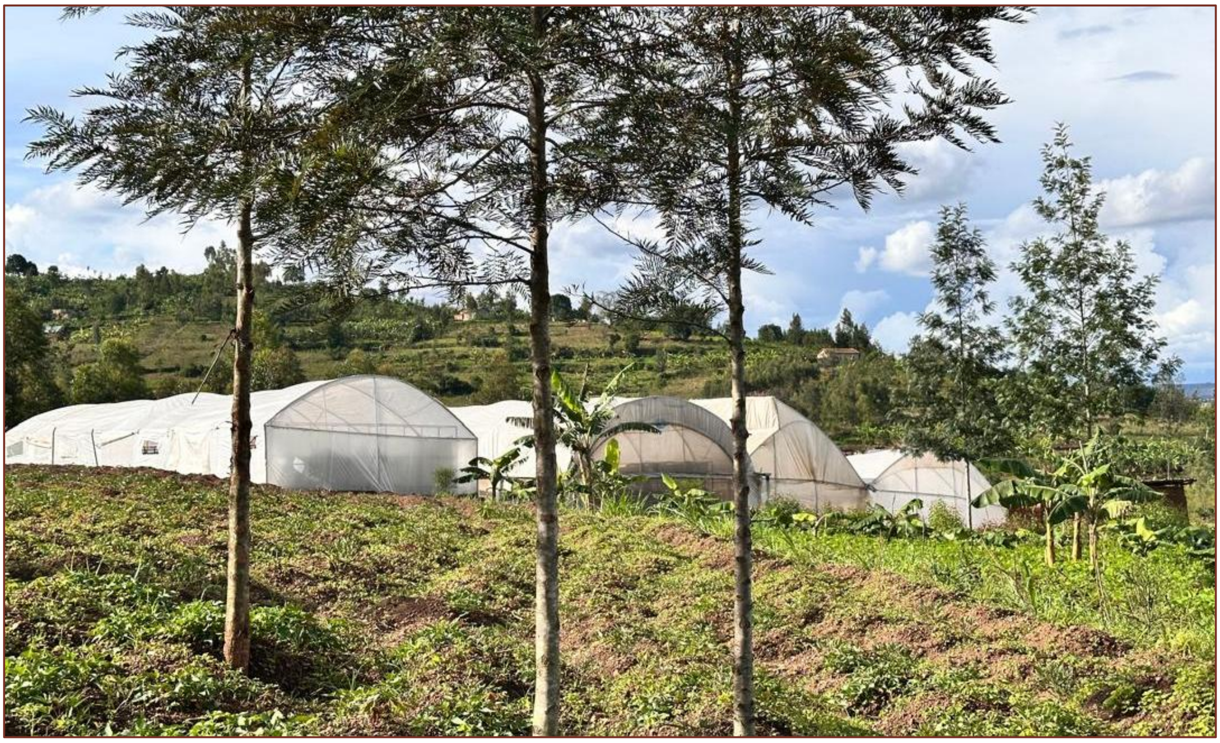
The RUNRES project is firmly committed to significant expansion. Several new entrepreneurs and innovations are preparing to start or scale operations with the support of RUNRES Phase II grants. Plans include increasing the volumes of BSF production through new partners and increasing HQCP production facilities. The project also aims to establish fully operational knowledge centers for BSFL and HQCPF innovations to support training and further dissemination.

Selection of Photos

Figure 4-10: Maggot Farm Productions Ltd, Kamonyi District, Rwanda

Source: IITA

Figure 4-11: Maggot Farm Productions Ltd, Kamonyi District, Rwanda



Source: IITA

Conclusion

5 Conclusion: Realizing the potential of BSF for a sustainable future in Africa

The comprehensive analysis within this policy guide clearly positions the BSF organic waste treatment solution as a transformative, multi-faceted way critical for advancing sustainable development across Africa. Facing escalating challenges in waste management, climate change, food security, and youth unemployment, BSF offers a pragmatic and powerful pathway, particularly for Sub-Saharan Nations with pressing organic waste problems and suitable climate conditions for BSF farming.

Multifaceted Benefits for African Contexts:

At its core, the BSF solution provides a robust and innovative mechanism for organic waste management. Many African regions contend with burgeoning populations and rapid urbanization, leading to an overwhelming accumulation of organic waste that often ends up in open dumps. This not only strains municipal services but also contributes significantly to environmental degradation. By diverting vast volumes of this biowaste from uncontrolled landfills and open dumping sites, BSF cultivation directly contributes to substantial climate change mitigation by preventing the release of potent methane emissions – a greenhouse gas which is around 28 times more powerful than carbon dioxide over a 100-year period. This bioconversion process is a cornerstone of the circular economy, transforming what was once considered waste into a cascade of valuable resources. The primary outputs include a protein-rich larval meal (available as live/fresh larvae, dried larvae, or highly refined protein meal after defatting) and nutritious fat. These products serve as sustainable, locally-produced alternatives to expensive conventional animal feeds like imported fishmeal, soy meal, and corn, thereby enhancing local food security, reducing reliance on costly imports, and stabilizing supply chains. Concurrently, the nutrient-dense BSF frass, the residual byproduct, serves as an effective organic soil conditioner and fertilizer, promoting vital soil health and structure, enhancing crop yields, and reducing dependence on synthetic chemical fertilizers. This full-spectrum valorization of waste embodies true resource recovery.

Beyond these profound environmental and economic advantages, BSF offers substantial and inclusive socio-economic benefits. The simplicity and adaptability of BSF farming create accessible and flexible entrepreneurship opportunities, particularly for women, allowing them to gain financial independence and contribute meaningfully to household incomes, often from their homes or within local communities. It also provides dynamic pathways for youth empowerment, offering green economy jobs and attractive alternatives to traditional, often less profitable, agricultural pursuits or urban migration. This fosters valuable skill development, stimulates local economies, and contributes to the revitalization of rural areas. Furthermore, Africa's widespread tropical and subtropical climates provide naturally favourable conditions for BSF farming. The prevalence of consistent warm temperatures and adequate humidity levels in numerous African countries offers a distinct advantage over regions with cooler or more extreme climates, significantly minimizing the necessity for expensive, energy-intensive climate control systems (such as continuous active heating, cooling, humidifying, or dehumidifying). This inherent climatic suitability directly reduces initial capital expenditure (CAPEX) for facility infrastructure and significantly lowers ongoing operational costs (OPEX), thereby bolstering the financial feasibility and overall profitability of BSF waste processing projects across the continent.

Strategic Imperatives for Implementation and Scaling:

To truly unlock BSF's transformative potential and ensure its widespread adoption, strong policy support and collaborative action across various sectors are indispensable. A critical first step involves acknowledging, valuing, and strategically integrating the informal waste management sector into formal BSF value chains. Recognizing their existing knowledge and infrastructure, rather than displacing them, will ensure a more equitable transition and sustainable waste sourcing. Overcoming the immaturity of the BSF value chain is also paramount. Currently characterized by a lack of coordination, limited production capacities, and often inconsistent product quality, this immaturity hinders market development and investment. Addressing these challenges requires fostering greater collaboration and coordination among producers, processors, and buyers, promoting specialization within the value chain, and establishing robust sectoral associations to drive collective growth. Increasing production volumes is essential not only to meet nascent demand but also to achieve economies of scale, stabilize pricing, and attract the necessary investment for large-scale facilities.

Effective and sustainable BSF implementation hinges on a proactive and adaptive policy environment. This includes:

- **Thorough policy diagnostics:** Before developing new policies or initiating large-scale BSF projects, a comprehensive review of existing national and sub-national waste management strategies, climate change adaptation and mitigation plans (including NDCs), agricultural development policies, and relevant economic frameworks is essential. This ensures that BSF technology is explicitly recognized and supported within the current regulatory landscape, identifying opportunities for integration and existing barriers.
- **Comprehensive feasibility studies:** Conducting detailed economic, social, and environmental assessments, specifically tailored to different scales and geographical locations, is important. These studies provide crucial data on potential costs and revenues, market dynamics for BSF products, broader socio-economic impacts (including employment generation and resource access), and environmental footprints (waste reduction, GHG emissions), ensuring initiatives are technically sound, economically sustainable, and socially acceptable.
- **Multi-Stakeholder engagement:** Convening multi-stakeholder workshops with representatives from municipalities, NGOs, agribusinesses, and community groups is an effective strategy to co-design BSF frameworks. These platforms facilitate shared understanding, collaborative problem-solving, and consensus-building on regulatory needs, market development, and community integration models, leading to the development of localized, contextually relevant, and widely supported BSF roadmaps or policy recommendations.

A vision for amplified climate ambition and sustainable prosperity:

Integrating BSF technology into national strategies presents a powerful means to significantly enhance national climate ambitions. By directly mitigating methane emissions from decomposing organic waste, BSF offers a crucial, high-impact contribution to a nation's NDCs. This innovative and scalable approach provides a cost-effective pathway to immediate climate action, complementing broader, longer-term decarbonization efforts by effectively "buying time" for more systemic transformations.

In conclusion, the strategic adoption and scaling of the BSF technology in Africa is more than just an innovative waste management technique; it is a catalyst for sustainable development across multiple dimensions. By prioritizing robust policy frameworks, fostering collaborative ecosystems that bridge formal and informal sectors, and thoroughly understanding local socio-economic and environmental nuances, countries like Uganda, Ethiopia, and Cote d'Ivoire can serve as powerful examples. They can demonstrate how nature-based solutions can drive inclusive economic growth, achieve ambitious climate goals, enhance food and resource security, and ultimately build more resilient and prosperous communities across the African continent. This guide serves as a foundational step towards that transformative vision.

Annex

6 ANNEX

6.1 Organic waste management challenges in Africa

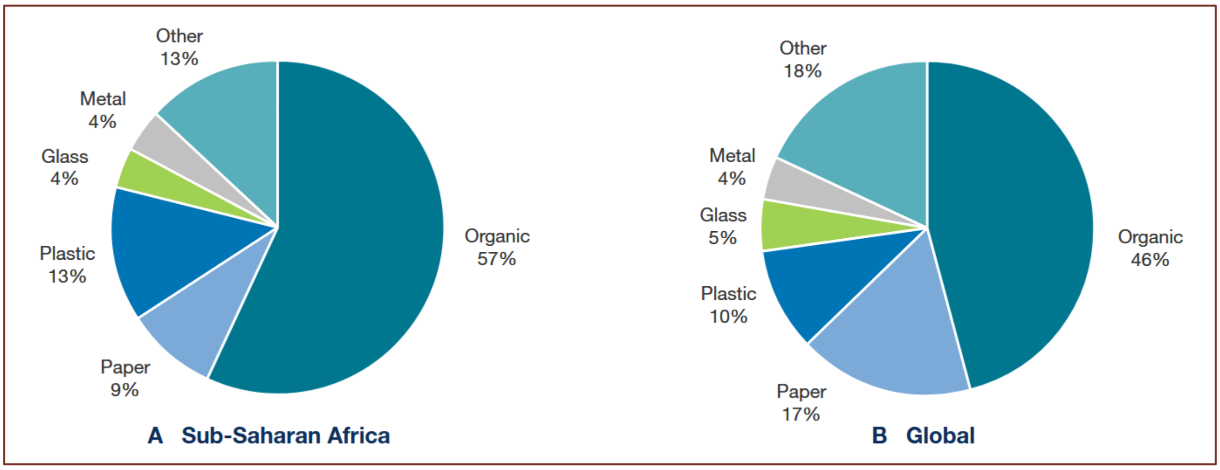
6.1.1 Current situation

The management of organic waste across African countries is a significant challenge, characterized by specific waste characteristics and prevailing disposal practices that necessitate effective and scalable solutions. Urbanization and population growth across the continent contribute to an increasing volume of waste, often outpacing the development of adequate municipal waste management infrastructure.

A defining feature of municipal solid waste (MSW) in African cities is its high organic content. Research indicates that the organic fraction of MSW in African cities typically ranges from 55% to 80%.[63] This composition is considerably higher than in many developed regions and is attributed to dietary patterns and prevalent use of organic materials.[64] This fact is illustrated in Figure 6-1, which is showing the composition of MSW waste in Sub-Saharan countries compared to the global average situation.

Despite this substantial proportion of putrescible material in the MSW waste in Africa, available data suggests that less than 10% of this organic waste is processed sustainably.[65]

Figure 6-1: MSW composition, sub-Saharan Africa and global



Source: UNEP & CSIR (2018). State of solid waste management in Africa.

The predominant waste management practices in many African urban and peri-urban areas involve limited collection services, leading to a significant portion of waste remaining

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[63] World Bank Group (2018). Publication: What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050.; UNEP (2018). African Waste Management Outlook.

[64] UNEP & CSIR (2018). State of solid waste management in Africa.

[65] World Bank Group (2018). Publication: What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050.

uncollected. Collected waste is frequently directed to open dumpsites or uncontrolled landfills. These sites often lack proper liners, leachate collection systems, and daily cover, representing basic disposal rather than engineered sanitary landfills. Furthermore, the lack of source segregation at the household level means that organic waste is often mixed with other waste streams, complicating subsequent recycling or treatment efforts.[66]

In the context of organic waste management, various technologies are currently employed or under consideration, each with distinct operational characteristics.

Composting is an aerobic biological process that converts organic waste into a stable, humus-like material. It is a well-established method, often implemented at varying scales. Advantages include its ability to produce a soil conditioner and its relatively straightforward operational principles for smaller scales. However, large-scale composting operations typically require substantial land area for windrows or enclosed systems, and the process can be slow, requiring several months to achieve full maturity.[67] Especially challenging is that the compost is a low value-added product and its profitable commercialization is not always easy. Although composting in countries in the Global South often rely on appropriate e low-tech equipment or even manual processes, lack of standardized processes and careful consideration and implementation of suitable composting conditions and quality control often leads to low quality compost, methane emissions due to anaerobic conditions in the compost pile as well as groundwater contamination because of leachate.

Anaerobic Digestion (AD) involves the decomposition of organic matter in the absence of oxygen, yielding biogas (a methane-rich gas) as fuel, and a digestate as fertilizer and soil amendment. AD offers the advantage of energy recovery while significantly reducing the volume of organic waste. However, AD systems often necessitate substantial capital investment for construction and infrastructure. Their operation typically requires higher level technical expertise, and feedstock purity can be a critical factor in their performance, with certain contaminants potentially inhibiting the process. Relevant is also that when burning the biogas in a gas engine to obtain electricity, the efficiency losses are around 60-70%. Heat of the burning process should be used in order to increase the energy efficiency.

In comparison to these methods the BSF biowaste conversion solution presents a distinct operational profile for organic waste management:

- **Processing efficiency and speed:** BSF larvae efficiently reduce the mass of organic waste, typically achieving significant volume reduction within a short period, often 10 to 14 days for larval growth.[68] This rapid conversion rate can allow for higher

[66] World Bank Group (2018). Publication: What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050.
[67] EAWAG (2017). Black Soldier Fly Biowaste Processing - A Step-by-Step Guide.
[68] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

throughput and a comparatively smaller operational footprint per unit of waste treated, which is an important consideration in areas with limited land availability.

- **Resource recovery and dual product output:** BSF technology transforms organic waste into two primary outputs: a protein- and fat-rich larval biomass suitable for animal feed, and a nutrient-rich frass that can be used as an organic fertilizer.[69] This dual product stream diversifies the economic opportunities associated with waste valorisation, as both outputs have market value.
- **Feedstock versatility:** BSF larvae exhibit a high degree of adaptability, capable of consuming a wide array of organic waste streams, including diverse food waste, agricultural residues, and certain types of manure and sewage sludge. This versatility allows BSF systems to be applied across various sources of organic waste common in African countries.
- **Scalability and adaptability:** BSF systems can be implemented at various scales, from decentralized community-level units to larger industrial facilities.[70] This inherent flexibility in scale can facilitate integration into different waste management schemes, including those in regions with developing collection infrastructure.

These operational attributes position BSF technology as a relevant option for enhancing organic waste management practices in African countries, contributing to more efficient waste processing and resource recovery within the existing and evolving waste management landscape.

6.1.2 Environmental, social, and economic challenges associated with unmanaged organic waste

The rapid urbanization and population growth across African countries, coupled with evolving consumption patterns, have led to an unprecedented surge in organic waste generation. This escalating volume, when inadequately managed, presents a multifaceted crisis, posing severe environmental, social, and economic challenges that undermine sustainable development efforts across the continent. The pervasive reliance on unsustainable waste disposal methods, such as open dumping and uncontrolled burning, exacerbates these issues, creating a complex web of interconnected problems.

One of the most pressing concerns is the direct contribution of unmanaged organic waste to significant environmental pollution. Open dumpsites, which are unfortunately widespread in many African urban and peri-urban areas, are hotspots for environmental degradation. The anaerobic decomposition of organic matter within these sites generates large quantities of methane emissions, a potent greenhouse gas with a global warming potential far exceeding

[69] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

[70] CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

that of carbon dioxide over shorter timescales. This directly contributes to climate change and regional warming trends.[71] Beyond atmospheric impacts, these dumpsites are major sources of groundwater contamination. As rainwater percolates through decomposing waste, it forms a highly toxic liquid known as leachate, laden with heavy metals, organic pollutants, and pathogens. This leachate infiltrates the soil, directly polluting aquifers and rendering vital water sources unsafe for consumption, irrigation, and other uses, thereby posing a severe threat to public health and ecological integrity.[72] Furthermore, the frequent practice of open burning of waste at these sites releases a cocktail of harmful airborne pollutants, including particulate matter, dioxins, furans, and volatile organic compounds (VOCs). These emissions not only degrade local air quality but also contribute to regional atmospheric pollution.

The unmanaged decomposition and burning of organic waste also contribute to the formation of tropospheric ozone, a harmful ground-level pollutant. Volatile organic compounds (VOCs) released from decomposing waste, alongside nitrogen oxides (NOx) from open burning, act as precursors that react in the presence of sunlight to form ozone.[73] This ozone gas formation impacts air quality significantly, contributing to respiratory illnesses in humans and negatively affecting crop production. Elevated ground-level ozone concentrations can damage plant tissues, reduce photosynthesis, and ultimately lead to substantial crop yield losses, threatening food security and agricultural livelihoods in already vulnerable regions.[74]

Beyond environmental degradation, the implications for public health are profound and often catastrophic. Uncontrolled waste sites become breeding grounds for disease vectors such as flies, mosquitoes, and rodents, leading to the increased incidence of vector-borne diseases like malaria, cholera, and dysentery.[75] Direct exposure to pollutants from burning waste can cause acute respiratory infections, asthma, and other chronic lung conditions, disproportionately affecting vulnerable populations, including children and waste pickers who often live and work in close proximity to these hazardous sites. The consumption of water or food contaminated by leachate runoff further exacerbates these health risks, leading to gastrointestinal illnesses and long-term health complications.

From an economic perspective, unmanaged organic waste represents a significant loss of valuable resources. Instead of being repurposed into beneficial products, organic waste is simply discarded, squandering its inherent value as a source of energy, nutrients, and organic matter. This results in direct economic losses from untapped markets for compost, biogas, and insect-based proteins, forcing countries to rely on costly imported alternatives for agricultural inputs and animal feed.[76] Moreover, the costs associated with managing the

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[71] IPCC (2021). Climate Change 2021- The Physical Science Basis.
[72] Njewa, J.B., et al. (2025). The impact of dumping sites on air, soil and water pollution in selected Southern African countries: challenges and recommendations.
[73] UNEP (2018). African Waste Management Outlook.
[74] Sharps, K. et al. (2021). Ozone-induced effects on leaves in African crop species.
[75]Kumar, C. & Bailey-Morley, A. (2022). Waste management in Africa - A review of cities' experiences.
[76] World Bank Group (2018). Publication: What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050.

health impacts (healthcare expenditure) and environmental remediation (e.g., water treatment, land rehabilitation) linked to improper waste disposal place immense financial burdens on national and municipal budgets, diverting funds from other critical development priorities.

Underlying these challenges are systemic socio-economic barriers, particularly prevalent in many African contexts. Fragmented policy frameworks and weak regulatory enforcement often hinder the implementation of comprehensive waste management strategies. There is frequently a lack of clear institutional responsibilities, overlapping mandates, or insufficient legal instruments to incentivize sustainable practices and penalize polluters. Furthermore, limited financing for circular economy projects and sustainable waste infrastructure remains a critical impediment. Despite the clear long-term economic benefits, initial investment costs, perceived risks, and a lack of innovative financing mechanisms often deter both public and private sector investment in robust waste management solutions. This systemic underinvestment perpetuates reliance on outdated and environmentally damaging practices, trapping many urban centres in a cycle of waste accumulation and associated negative impacts.

7 List of references

Africa Circular (2025). Black Soldier Fly Opportunities Explored in Uganda, Ethiopia, and Ivory Coast.

Barragán-Fonseca, K.B., et al. (2024). Review – Insect farming for food and feed in the Global South: Focus on black soldier fly production.

CCAC (2024). Short-Lived Climate Pollutants - Pollutants with strong warming potential and significant impacts on health and the environment.

CCAC (2025). CCAC TEAP Report: Transforming Organic Waste with Black Soldier Flies: A Guide for Decision-Makers, Entrepreneurs, and Implementers to Unlock the Organic Waste Potential of Black Soldier Fly Systems.

CCAC (2025). Elevating Waste Solutions: Biocovers and Black Soldier Fly Technology.

CCAC (2025). Supporting Argentina from NDC to Action - Methane Reductions through Organic Waste Diversion & Use.

CGIAR & International Water Management Institute (2020). Global Experiences on Waste Processing with Black Soldier Fly (Hermetia illucens): From Technology to Business.

Chineme, A., et al. (2022). African Indigenous Female Entrepreneurs (IFÉs): A Closed-Looped Social Circular Economy Waste Management Model.

EAWAG (2017). Black Soldier Fly Biowaste Processing - A Step-by-Step Guide.

ECN - European Composting Network.

EPA (2023). Quantifying Methane Emissions from Landfilled Food Waste.

FAO (2013). The contribution of insects to food security, livelihoods and the environment.

FAO (2023). Mapping of the Black Soldier Fly value chain in East Africa.

GreenCape (2023). Industry Brief: Black Soldier Fly agriculture - Upcycling Cape Town's organic waste into local, climate friendly, and resilient feed for livestock, pets and the soil.

IIASA (n.a.). Uganda Sector Strategy for Organic Waste Management (SOWU).

IPCC (2021). Climate Change 2021- The Physical Science Basis.

Kumar, C. & Bailey-Morley, A. (2022). Waste management in Africa - A review of cities' experiences.

Lawrence, N.C., et al. (2021). Nitrous oxide emissions from agricultural soils challenge climate sustainability in the US Corn Belt.

Menegat, S., Ledo, A. & Tirado, R. (2022). Greenhouse gas emissions from global production and use of nitrogen synthetic fertilisers in agriculture.

Mertenat, A., Diener, S. & Zurbrügg C. (2019). Black Soldier Fly biowaste treatment – Assessment of global warming potential.

Njewa, J.B., et al. (2025). The impact of dumping sites on air, soil and water pollution in selected Southern African countries: challenges and recommendations.

PREVENT Waste Alliance (2024). BUGS Project: Biomass Utilization by Insects for Green Solutions in Africa through Black Soldier Fly Technology.

Raucci, G.S., et al. (2015). Greenhouse gas assessment of Brazilian soybean production: a case study of Mato Grosso State.

Rolland, C., Scheibengraf, M. (2003). Biologisch abbaubarer Kohlenstoff im Restmüll.

Salam, M. et al. (2022). Effect of different environmental conditions on the growth and development of Black Soldier Fly Larvae and its utilization in solid waste management and pollution mitigation.

Sharps, K. et al. (2021). Ozone-induced effects on leaves in African crop species.

Shindell, D. et al. (2012). Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security.

Smetana, S. et al. (2023). Environmental impact potential of insect production chains for food and feed in Europe.

Tanga, C.M. & Kababu, M. (2023). New insights into the emerging edible insect industry in Africa.

UNCDF (2023). Empowering Women and Youth in Uganda's Kalangala Islands Through Black Soldier Fly Farming.

UNEP & CCAC (2022). Global methane assessment: 2030 Baseline Report.

UNEP & CSIR (2018). State of solid waste management in Africa.

UNEP (2018). African Waste Management Outlook.

UNEP (2021). Global Methane Assessment – Summary for decision makers.

UNFCCC (2025). Nationally Determined Contributions (NDCs) - The Paris Agreement and NDCs.

VERRA (2024). Methodology for Black Soldier Fly Larvae Disposing of Organic Waste.

WHO (2025). Air pollution.

World Bank Group (2018). Publication: What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050.

World Bank Group (2025). Ease of Doing Business rankings.

ABOUT THE CCAC

The UNEP-convened Climate and Clean Air Coalition (CCAC) is a voluntary partnership of more than 190 stakeholders including more than 91 country partners seeking to reduce methane and other super pollutants to limit global warming to 1.5°C. Through its Trust Fund, the CCAC supports countries to reduce super pollutants emissions across sectors by 2030, while advocating for elevated ambition and advancing the latest in policy-relevant science. Different funding windows exist, including for institutional strengthening, national planning, policies and regulation as well as sectoral transformation.

Following a decade of success in raising global methane ambition, the CCAC Secretariat is also providing secretariat functions to the Global Methane Pledge (GMP), a voluntary commitment of more than 150 countries to reduce global methane emissions by at least 30% by 2030 compared to 2020 levels.

CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS
a UNEP convened initiative

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