Platform for Alternative Feed Ingredients Evaluation (PAFIE) – Black soldier fly larvae (BSFL)

PI and Co-PI: Emily Ouma and Ben Lukuyu

Donor: Gates Foundation

Project duration: Dec 2024 – Dec 2028

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Overarching goal

To evaluate innovations that could accelerate the production of black soldier fly larvae (BSFL) as an alternative feed protein ingredient for small-scale farmers in Africa

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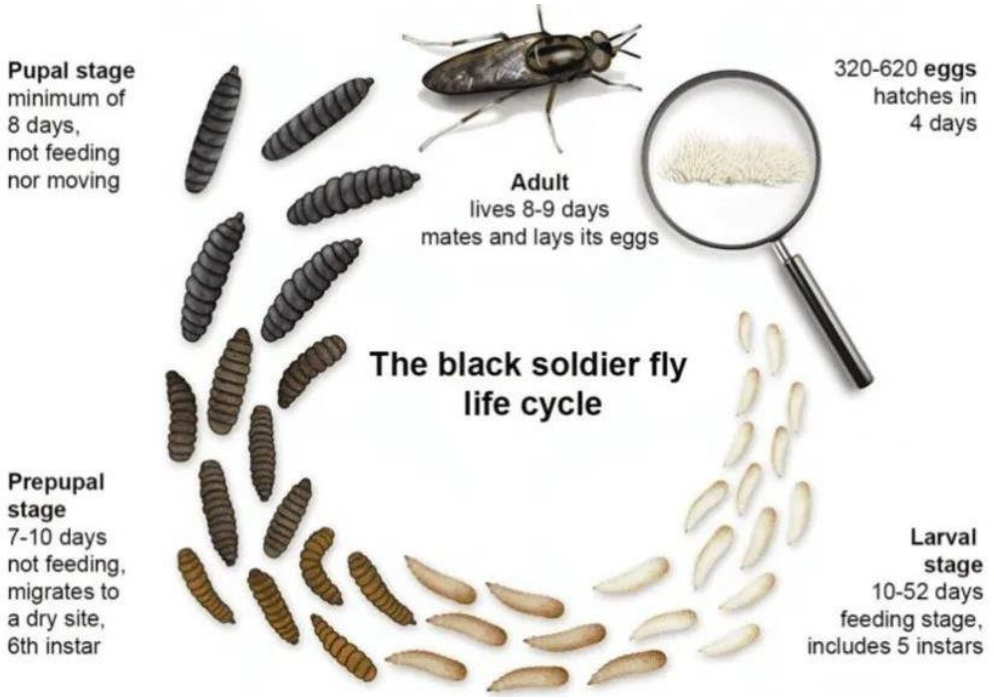
Rationale – Why it matters

- High volatility in the supply and price of key feed ingredients, especially proteins
- Main ingredients used in commercial feeds are plant-based sources, particularly corn and soybean
  - Fluctuations in supply ⟶ domestic production is rainfed and productivity remains low
  - High demand for soybean outpacing supply – price ⇧
- Unaffordability and poor access to quality feeds by many small-scale farmers result in low livestock productivity
- Alternatives that can reduce the reliance on soybean required

Opportunity

- Insect-based feeds for livestock show great potential due to their high protein content and balanced essential amino acids
- Tailored substrates and specific insect metamorphosis can lead to premium feed production
- Black soldier fly larvae-based meal gaining traction among aquaculture and livestock farmers in several African countries
- BSFL offers a consistent year-round supply, mitigating uncertainties related to seasonal cost variability

Black soldier fly contributes to a circular economy



- The larvae feed off organic waste collected from local markets and fields – addresses waste disposal challenge.
- Turns organic waste into high protein larvae (BSFL)
- Utilization
  - feed ingredient for poultry, pigs and fish
  - Organic frass to fertilize crop fields
- BSFL is mainly protein (>45%) and fat (>20%) and contain high levels of the most limiting amino acids such as lysine

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Problem statement

- Increasing interest and private sector investments in BSFL as an alternative protein source for livestock feeds
  - Still unclear whether it can be profitably produced at scale to drive the livestock feed sector in Africa to enable reliable and affordable access to small scale farmers

- Current BSFL value chain is rudimentary, with actors trying to produce their own larvae using various waste streams

Scaling readiness of an innovation package: Liebig's barrel

Problem statement

- Bioconversion efficiency of small-scale entrepreneurs remains low (less than 10%) compared to specialized companies (also struggling)
- Fluctuations in BSF egg production along the year due to climatic factors.
    - Eggs determine the volume of larvae that can be reared – thus a limiting factor to scaling
- Logistics costs associated with waste collection, sorting and transport
- Need for a scalable model for reducing costs while improving operational and bioconversion efficiency

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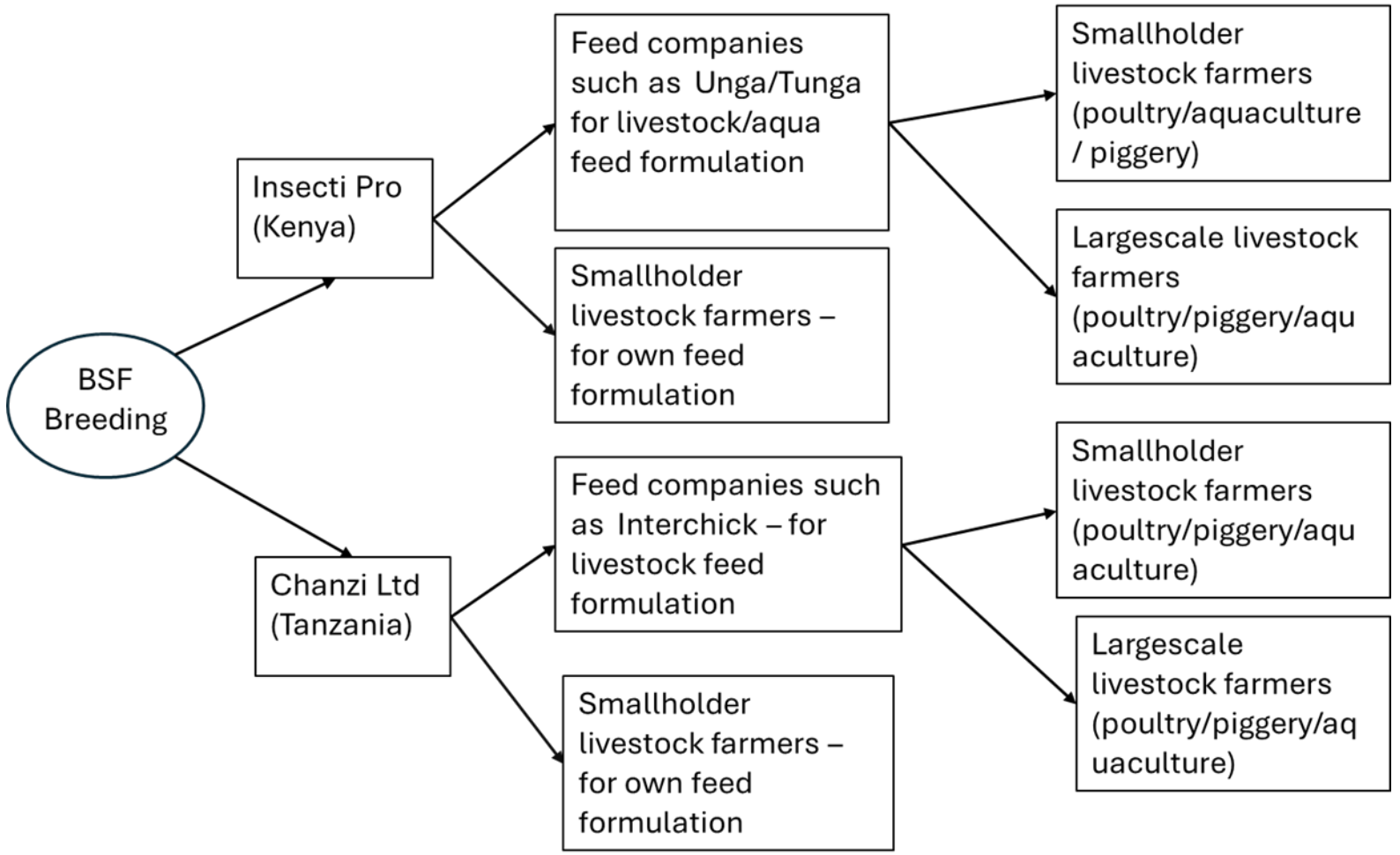
Proposed model

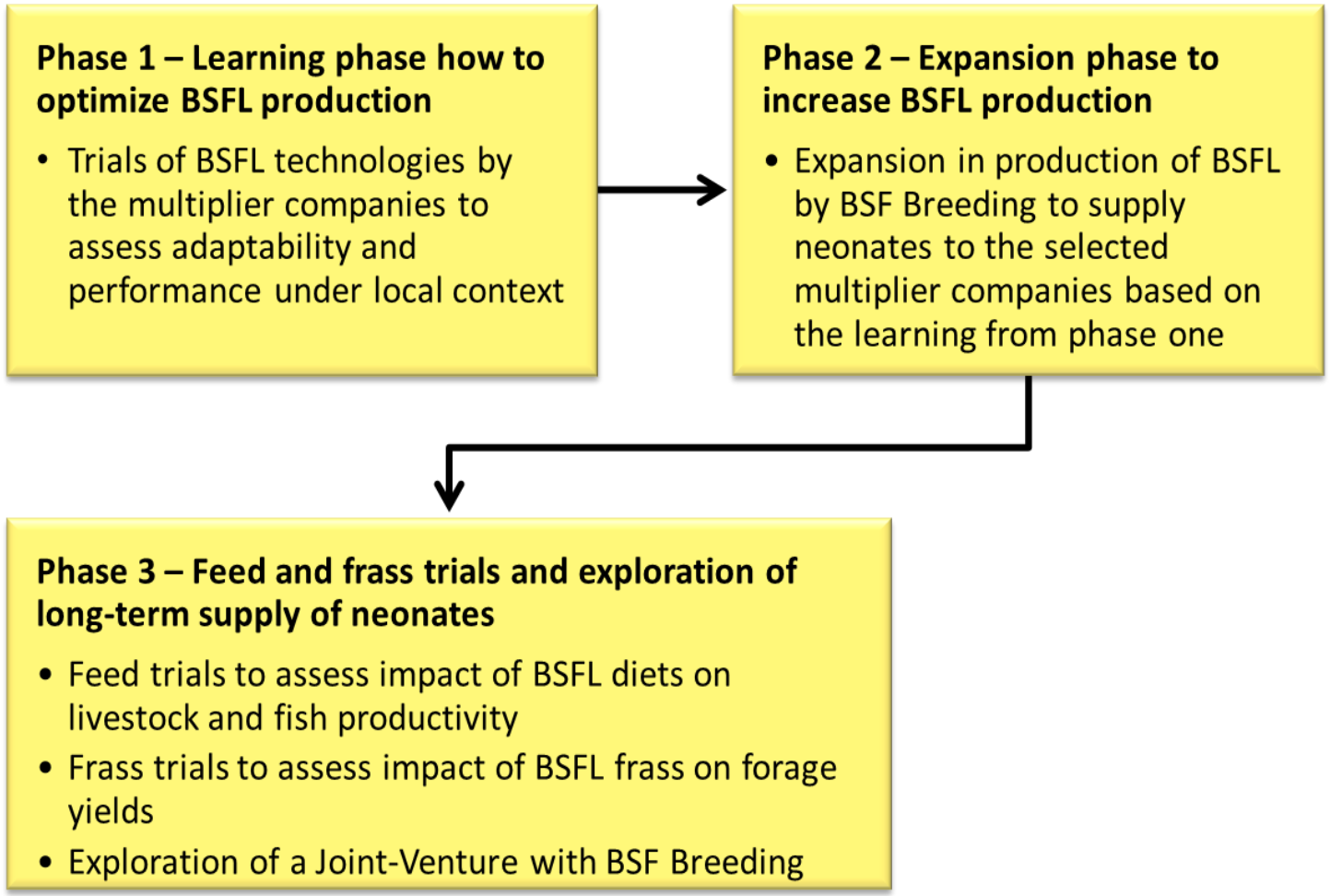
- Business model with enhanced value chain linkages (upstream actors (specialized BSF breeding technology platforms) to downstream actors

- Optimized production system that utilizes waste streams to produce larvae and efficiently convert it to feeds by utilizing standard protocols



Proposed model

- ILRI is collaborating with feed and BSF industry partners to generate evidence on the BSFL innovations that could:
  - Impact the scalability and economic feasibility of BSFL production along the value chain
  - Impact on small scale producers' livestock productivity and incomes
  - Reduce dependency on soybean as a protein source
- Implementation in 3 phases:

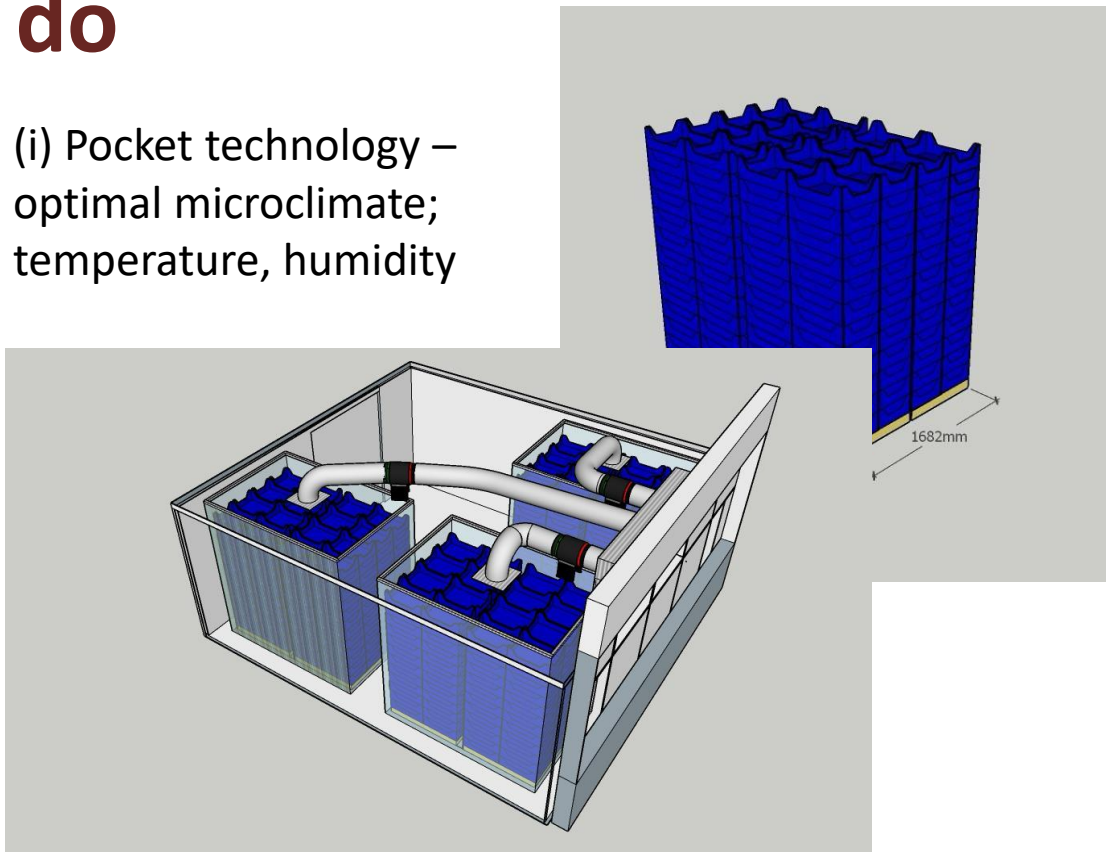


Project objectives - what we will do

1. Test innovations from BSF Breeding under local production systems (and using local waste streams) of multiplier companies in Eastern Africa to inform BSF technology development for the region and scaling.

2. Evaluate the performance of BSF breeding innovations:
   - Impact on bioconversion efficiency
   - Neonate metrics (survivability, uniformity of 5dol, egg cost per crate),
   - Larval production metrics (growth time, harvest quantity, fat content, protein content)

(i) Pocket technology – optimal microclimate; temperature, humidity



(ii) Neonate larvae from quality BSFL parent stock

Objective 1: To test innovations from BSF Breeding under local production context and assess performance under local context

Key research questions

- How effective is the pocket technology in terms of the feed conversion rate and BSFL grow-out time compared to the current production systems of the 2 companies? (Current system: crate system by Insect Pro; deep litter system by Chanzi Ltd)
- How does the yield of BSFL from neonates from BSF Breeding compare with the 2 companies' own neonates and production system?
- What is the financial viability of the BSFL business with the pocket technology, and neonates from BSF Breeding compared to the current production system? (Are they cash flow positive)?)

Objective 1: To test BSF technologies from BSF Breeding under local production context and assess performance

Evaluation through 4 experiments

BSF Breeding will erect 4 pockets (92 trays in each), that can be operated in one 40-foot reefer container which can hold 10 tonnes of feed, at InsectiPro (Kenya) and Chanzi Ltd (Tanzania) facilities.

- **Experiment 1**: BSFL technologies comprising the pocket technology and neonates from BSF Breeding
- **Experiment 2**: Pocket technology from BSF Breeding and neonates from Insecti Pro.
- **Experiment 3**: Neonates from BSF Breeding using Insecti Pro's current production crate system using 2.5 tons of feed.
- **Experiment 4**: Use of Insecti Pro's neonates and current production crate system using 2.5 tons of feed (control)

Financial model for the 4 experiments will be evaluated to assess feasibility.

Project objectives - what we will do

3. Optimize BSFL-based compound poultry and fish feed formulations to determine the optimal inclusion rates that leads to least cost formulation compared to conventional ingredients
4. Evaluate the impact of BSFL-based feeds on poultry and aquaculture fish productivity and its cost-effectiveness, and profitability for small-scale farmers
5. Evaluate the impact of frass derived from BSFL on maize and legume forage yields and quality, and profitability in Kenya and Tanzania

Better lives through livestock

Objective 3: Optimizing BSFL-based Feed with Private sector

Enhancing Fish and Poultry Nutrition

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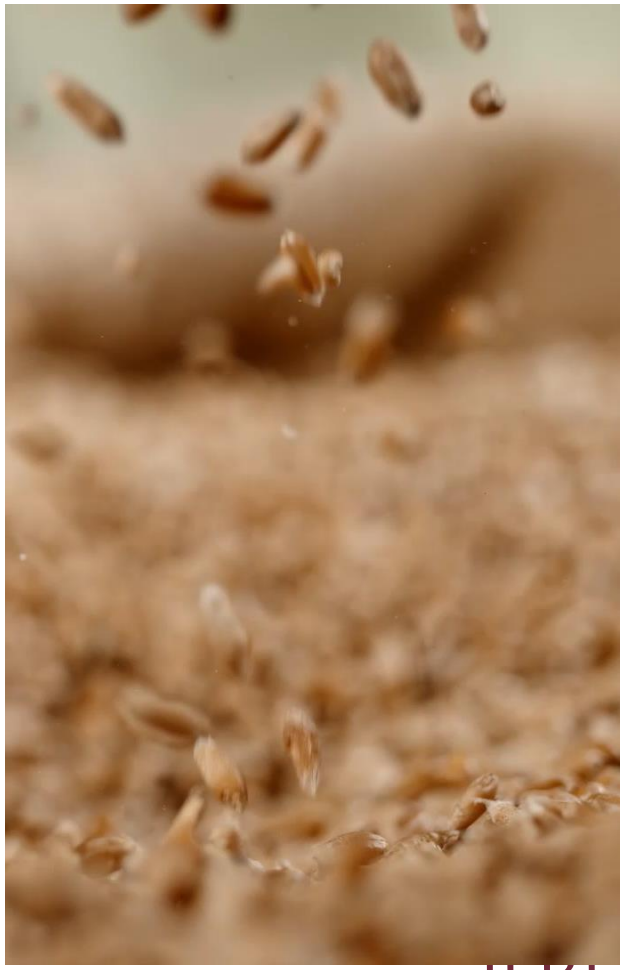
Insect-Based Feeds: A Promising Alternative

- **Insect-based feeds:** A promising alternative for livestock feed due to high protein content and balanced amino acid profile.
  - Insect meal can partially replace conventional protein sources like soybean or fish meal.
  - Consistent year-round supply mitigates feed reliability and cost fluctuation issues.
  - BSFL require minimal resources, reducing feed formulation costs.
  - BSFL enhance feed quality with essential amino acids and nutrients, improving livestock health and performance.



Addressing BSFL Supply Gaps in the Feed Industry

- **Challenge:** Feed industry reports insufficient BSFL supply for cost-effective production.
- **Root cause:** Inconsistent BSFL quantities from various small-scale producers and aggregators.
- **Consequence:** Variable BSFL quality complicates feed formulation.
- **Intervention:** Formulate and validate high-quality BSFL-based diets with feed industry stakeholders to ensure a consistent, affordable supply.

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BSFL Feed Formulation Partnerships in Kenya and Tanzania

- **Partnering companies:** To be selected through rigorous process
- **Focus:** Optimize BSFL feed formulations for fish and poultry (broilers).
- **Implementation:** Will be managed through selected Feed Companies in Kenya and Tanzania via Sub-awards.

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Activity 3.1: BSFL & Feed Ingredient Nutritional Profiling

Objective: Determine the complete nutritional profile of BSFL (wet and dry) and common feed ingredients.

Analysis: Proximate, mineral, amino acid, and fatty acid composition. Assess anti-nutritional factors and risks (mycotoxins, heavy metals, pathogens).

Question: How do BSFL meal and feed ingredient nutritional profiles meet the needs of target poultry and fish?

Expert Team & Feed Company Selection

Expert Team (3-4 NARS Nutritionists): Assess and shortlist feed companies in Kenya and Tanzania based on their capacity to formulate and produce livestock diets; and conduct controlled feeding trials with BSFL.

Company Assessment: The team will develop clear, objective criteria for selecting two feed companies (one large, one small), based on formulation capacity, feed production capabilities, and trial expertise.

Shortlisting & Validation: Use a validated evaluation tool, conduct site visits to confirm information, and finalize recommendations.

Industry Engagement: Engage AKEFEMA/TAFMA to support the selection process.

Onboarding Selected Feed Companies

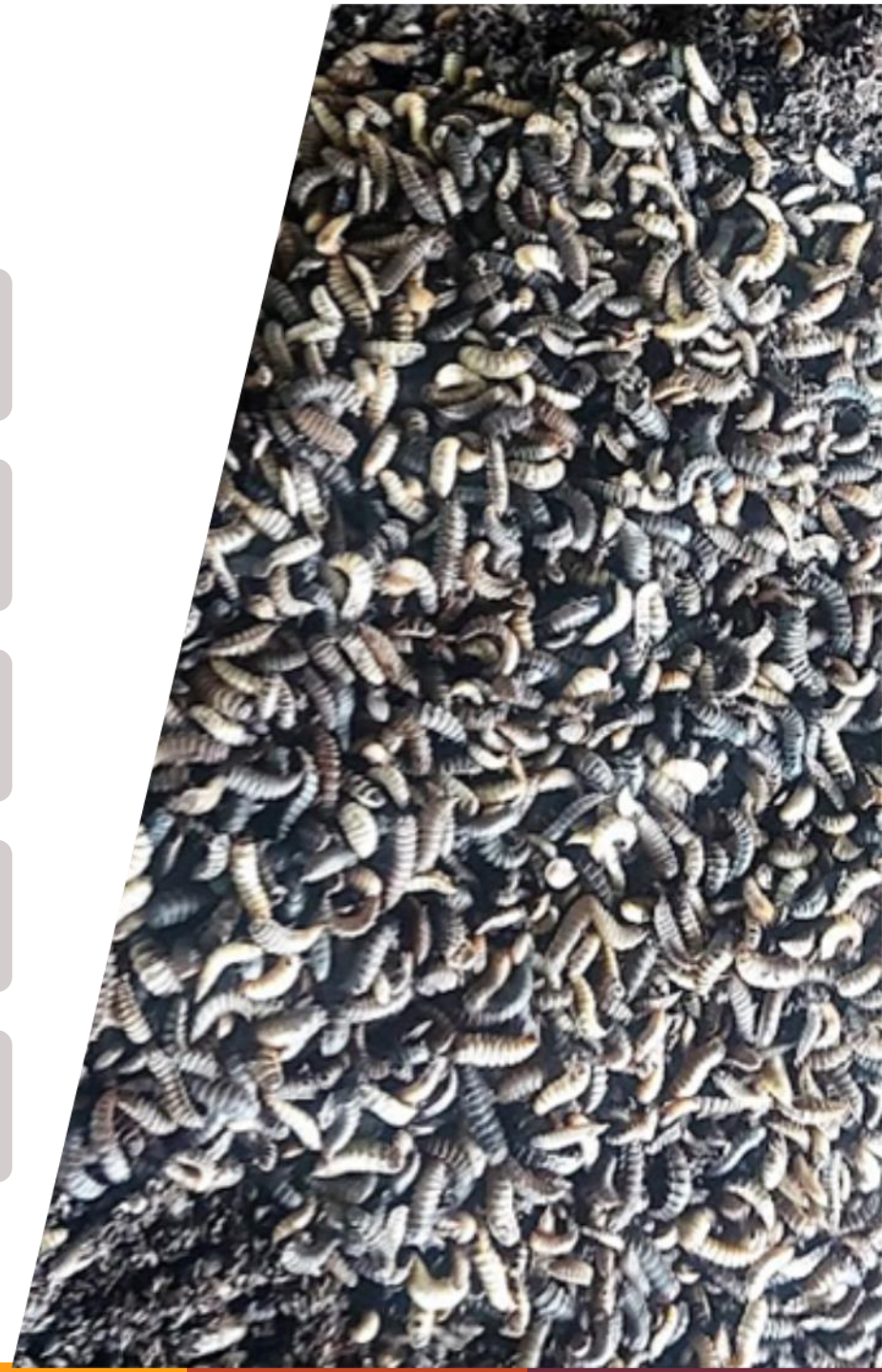
Discussions: ILRI will discuss company vision and long-term commitment to BSFL (Scaling).

Feed analysis & optimization: Plan feed analysis and optimisation of BSFL-based diets.

Trial Workplans: Agree on feeding trial workplans and fish/poultry feed production schedules.

Diet Production: Agree on production of experimental diets for pilot studies, followed by bulk production for farmer validation.

Sub-Awards: Prepare and sign sub-award agreements.



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BSFL Feed Formulation & Analysis

Input: Nutritional analysis data (Activity 3.1)

Process: Formulate fish and poultry feed with varying BSFL inclusion levels.

Analysis: Chemical analysis of BSFL and conventional diets.

Question: How do macro/micronutrient profiles of BSFL-based feeds compare to conventional feeds at different inclusion levels?

Pilot Performance Trials

- **Diets:** BSFL-based feed rations from Activity 3.2 and conventional soy-based control diet.
- **Trials:** Controlled environment trials with fish and poultry.
- **Measurements:** Growth performance, feed conversion ratios, health, palatability.
- **Output:** Selection of promising diets for expanded on-farm trials in Phase 2.
- **Research Question:** How do growth performance and feed conversion ratios of fish and poultry fed BSFL-based diets compare to those fed conventional diets?

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Objective 4: Feed Production, Validation Trials & Dissemination

Feed production: Selected companies produce bulk BSFL-based experimental and conventional control diets for farmers to ensure consistency and trial needs.
Feed procurement & supply: Project purchases and supplies formulated feed directly to participating farmers, simplifying logistics and ensuring correct rations.
On-farm trials: Validate BSFL inclusion in fish and poultry diets with farmers, measuring impacts on productivity (growth rates, feed conversion).
Dissemination: Share findings with farmers, feed manufacturers, researchers, and policymakers.

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Objective 5: Evaluating the Effects of Black Soldier Fly Larvae Frass on Forage Crop Production in Kenya and Tanzania

Enhancing Forage Yield and Quality through Sustainable Fertilizer Practices

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BSFL Frass: A Sustainable fertilizer

Problem: Conventional fertilizers cause nutrient runoff, GHG emissions, and soil degradation.

Solution: Sustainable agriculture requires alternative fertilizers.

Circular economy: Insect frass converts waste into a valuable resource.

Nutrient-Rich: BSFL frass is a nutrient-rich (N, P, K) organic fertilizer for soil amendment [Moral, 2024][Houben et al., 2020][Lopes et al., 2022].

Soil health: Improves soil structure, water retention, and microbial activity [Moral, 2024].

Pest & disease suppression: Reduces need for chemical interventions [Moral, 2024].

Low carbon footprint: Frass production is more sustainable than conventional fertilizer [Insect Frass - World's Most Sustainable Fertilizers, 2021].

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BSFL Frass for Forage Crops in Kenya

Focus: Evaluating BSFL frass as a sustainable fertilizer for forage crops.

Study Locations:

- Nakuru County (with Venture 37, in 2025)
- Kajiado & Samburu Counties (leveraging upcoming ILRI PAFIE project, 2026)
- ILRI Kapiti Wildlife Conservancy

Frass Supplier: InsectiPro Ltd

Goal: Evaluate BSFL frass as a replacement for inorganic fertilizers.

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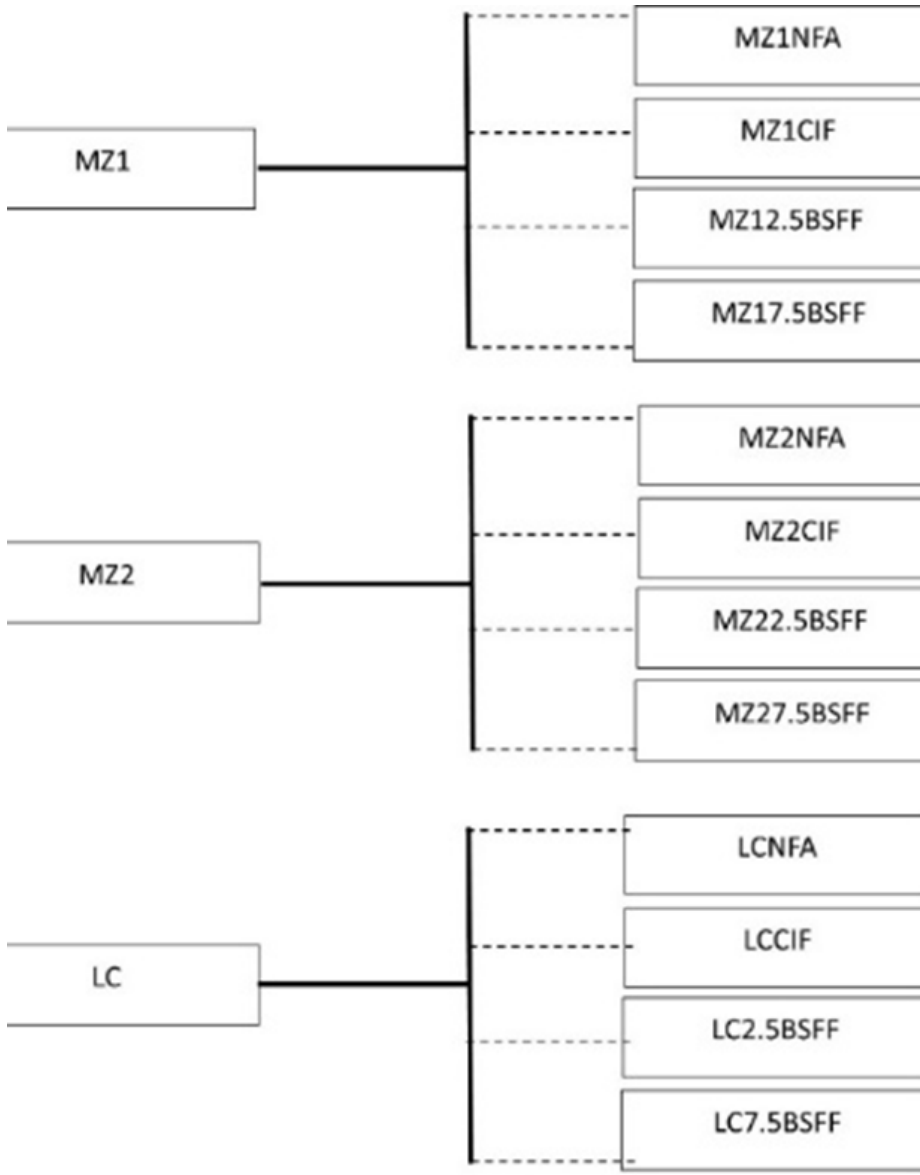
Research Questions

- How does frass affect forage crop yields compared to conventional fertilizers?
- What are the nutritional benefits of frass on forage quality?
- What is the cost-effectiveness of frass compared to inorganic fertilizers?

Experimental design

- Design
  - Control plot (no fertilizer).
  - Frass treatments. Varying application rates based on prior research and recommendations.
  - Inorganic fertilizer treatment. Standard application rate for the region/crop.
- Forage varieties: Two varieties (Forage sorghum [grass]and Lucerne [legume]).



Soil Analysis Protocol

Baseline sampling: Collect soil samples systematically across each plot *before planting*.

Composite samples: Combine samples to reflect site diversity and forage nutrient needs.

Key nutrients: Analyse for pH, organic matter, N, P, K, and micronutrients.

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On-Farm Trials with Mogotio Dairy Cooperative, in Baringo County

Location: Mogotio dairy cooperative society, Kenya

Trial design: Select four farmers each for sorghum and Lucerne forage planting experiments.

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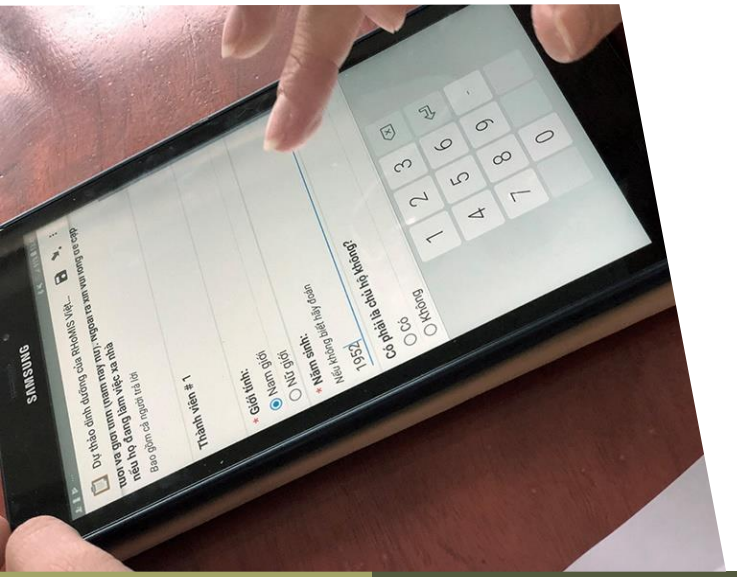

Data Collection and Analysis

Data collection:

- Measure forage growth (yield, height, biomass)
- Assess quality (protein, digestibility)
- Monitor soil health indicators

Data analysis:

- Statistically compare frass, inorganic fertilizer, and control treatments across zones and countries.

Economic assessment:

- **Input costs:** Quantify costs for frass and conventional fertilizer (fertilizer, transport, storage, labour).
- **Yield output:** Measure crop yield (kg/ha, tons/acre).
- **Profitability analysis:** Compare total costs and revenue (yield x market price) to determine profitability of each fertilizer treatment.

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Assessing farmer perceptions on use of frass

- Qualitative data collection:
  - Conduct farmer surveys and interviews, including focus group discussions, to gather perceptions, challenges, and opportunities related to frass use
- Focus group discussions:
  - Conduct eight sex-disaggregated FGDs per AEZ in each country, ensuring balanced representation of male and female farmers.
- Data processing:
  - Audio-record, transcribe, and translate (if necessary) all FGDs into English.
- Data analysis:
  - Code and analyse the qualitative data using appropriate software.

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Farmer feedback sessions

- **Participant recruitment:**
  - Recruit smallholder farmers from the selected locations who will participate in the trials.
- **Training and information sharing:**
  - Provide participants with a plenary lecture-style training on BSF frass, including sharing key results and lessons learned from the field trials.
- **Transcription and translation:**
  - Ensure all audio recordings are transcribed and translated into a common language for analysis
- **Data cleaning and organization:**
  - Develop a coding framework based on key themes and research questions.
  - Use qualitative data analysis software to systematically code the transcripts.
- **Interpretation and reporting:**
  - Interpret the identified themes in the context of research objectives.
  - Summarize findings in a clear and concise report, using illustrative quotes from farmers to support key points.

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